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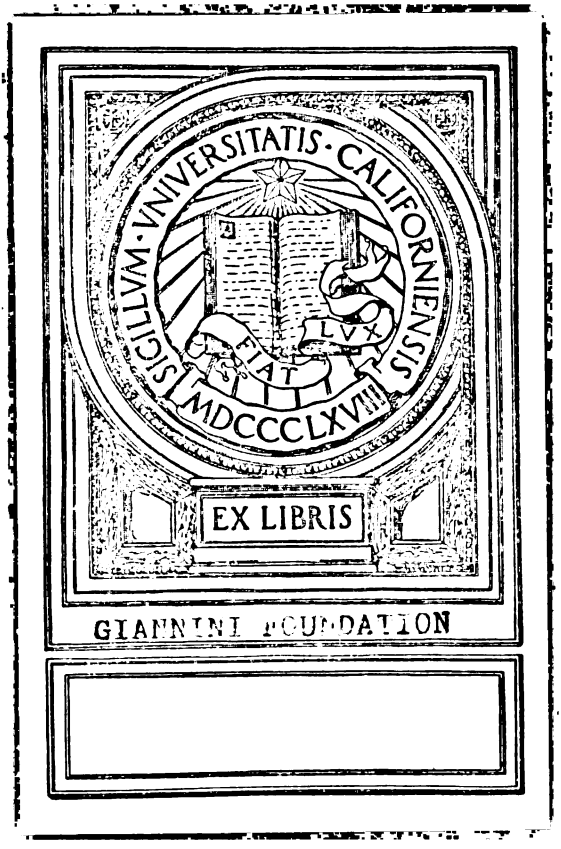

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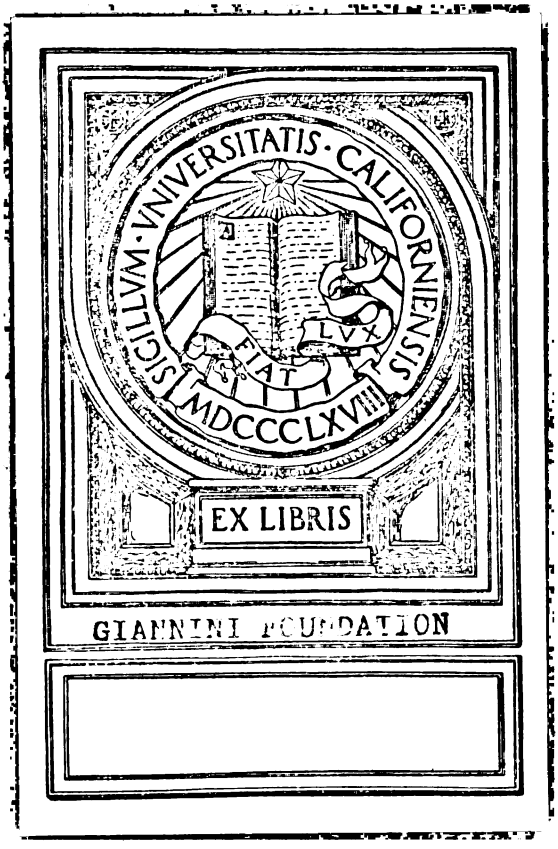

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REPORT

OF THE

CONSERVATION COMMISSION

OF THE STATE OF CALIFORNIA

TO THE

GOVERNOR AND LEGISLATURE OF CALIFORNIA

1912

FRIEND WM. RICHARDSON, SUPERINTENDENT OF STATE PRINTING
SACRAMENTO, CALIFORNIA
1912

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REPORT

OF THE

Conservation Commission

OF THE

State of California

January 1, 1913

Transmitted to the Governor and the Legislature
January 1, 1913

FRIEND WM. RICHARDSON, SUPERINTENDENT OF STATE PRINTING
SACRAMENTO, CALIFORNIA
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LETTER OF TRANSMITTAL.

SACRAMENTO, CALIFORNIA.

To the Governor and the Legislature of California:

In compliance with the provisions of Chapter 408, Statutes of 1911, creating and establishing this Commission to investigate and report on certain specified subjects of conservation, and to recommend legislation relative thereto, the Commission begs to submit this report and the exhibits hereto attached.

Respectfully submitted this 1st day of January, 1913.

CONSERVATION COMMISSION OF THE STATE OF CALIFORNIA.

GEORGE C. PARDEE, Chairman.
FRANCIS CUTTLE.
J. P. BAUMGARTNER.

LOUIS R. GLAVIS, Secretary.

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ACT CREATING COMMISSION.

The Conservation Commission was created by the following act of the legislature:

CHAPTER 408.

An act creating and establishing a commission for investigating and gathering data and information concerning the subjects of forestry, water, the use of water, water power, electricity, electrical and other power, mines and mining, mineral and other lands, dredging, reclamation and irrigation, and for revising, systematizing and reforming the laws of this state upon, concerning, regarding or appertaining to these said subjects; providing for the appointment of said commission to be known as the "Conservation Commission of the State of California"; prescribing the powers and duties of said commission and its members and providing for the expenses of said commission and appropriating money therefor.

[Approved April 8, 1911.]

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. A commission consisting of three persons which shall be known and designated as the "Conservation Commission of the State of California," is hereby created and established for the purpose of investigating and gathering data and information concerning the subjects of forestry, water, the use of water, water power, electricity, electrical or other power, mines and mining, mineral and other lands, dredging, reclamation and irrigation, and for the purpose of revising, systematizing and reforming the laws of this state, upon, concerning, regarding or appertaining to these said subjects.

SEC. 2. Said commission shall be appointed by the governor, and shall enter upon the performance of its duties immediately. The members of said commission shall hold office at the pleasure of the governor. In case of a vacancy in said commission, such vacancy shall be filled by appointment by the governor.

SEC. 3. It shall be the duty of said commission to investigate and examine the laws of the United States, of foreign nations, of the states of the union and of this state, and the reports and recommendations of persons, officials, commissions, societies and associations upon the subjects of forestry, water, the use of water, water power, electricity, electrical and other power, mines and mining, mineral and other lands, dredging, reclamation and irrigation and to prepare and recommend to the legislature laws, statutes and constitutional amendments revising, systematizing and reforming the laws of this state upon forestry, water, the use of water, water power, electricity, electrical and other power, mines and mining, mineral and other lands, dredging, reclamation and irrigation. The said commission is hereby authorized and empowered to do and perform the acts and things required of it by this act, and to adopt all rules and regulations necessary to carry out the provisions of this act.

SEC. 4. The said commission is hereby empowered and authorized to have printed by the state printer its reports, records and proceedings in the manner provided by law.

SEC. 5. It is hereby made the duty of the attorney general, serveyor general, the state engineer and all other state officers to render such aid and assistance to said board as said board may require.

SEC. 6. For the purpose of carrying out the provisions of this act the said commission is authorized to employ such expert, technical, professional and clerical assistance and upon such terms as it may deem proper.

SEC. 7. In order to carry out the provisions of this act the members of said commission or any person authorized by it are authorized to enter and cross all lands within this state, and to make all proper and necessary surveys and measurements of land and water; *provided*, that in doing so no damage is done to private property; and it shall be a misdemeanor, for any person or persons to wilfully and maliciously remove or destroy any permanent marks or monuments made or erected by said commission or any person or persons under its direction or authorization, or to prevent the members of the said commission or any person authorized by said commission to enter and cross any land within this state or to make surveys and measurements of land and water.

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SEC. 8. Said commission shall receive no salary for their services but shall be allowed their actual expenses while in the performance of their duties as in this act provided.

SEC. 9. The sum of $100,000 is hereby appropriated out of the funds of the state not otherwise appropriated for the purposes of carrying out the provisions of this act, and the state controller is hereby authorized and directed to draw warrants upon such sum from time to time upon the requisition of said conservation commission approved by the board of examiners, and the state treasurer is hereby authorized and directed to pay such warrants.

SEC. 10. All acts or parts of acts in conflict herewith are hereby repealed.

SEC. 11. This act shall take effect immediately.

PERSONNEL OF COMMISSION.

The Governor appointed the following as members of the Commission: George C. Pardee, of Oakland, who was chosen by the Commission as its chairman; Ralph W. Bull, of Eureka; Francis Cuttle, of Riverside. Mr. Bull, owing to press of private business, resigned in August, 1911, and J. P. Baumgartner, of Santa Ana, was appointed in his place. Louis R. Glavis was appointed secretary on August 12, 1911.

FINANCIAL STATEMENT OF COMMISSION.

The sum of $100,000.00 was appropriated for the purposes of this Commission. Of this amount $54,760.18 has been expended in the course of eighteen months, that is to say, from May 1, 1911 to November, 1912.

Appropriation		$100,000 00
Co-operative agreement with U. S. Geological Survey	$14,615 27	
Co-operative agreement with U. S. Department of Agriculture	15,546 58	
Salaries	8,364 51	
Office expenses	2,656 78	
Traveling expenses	2,243 67	
Contingent (including collecting of certain data and other information)	5,803 94	
Commissioners' expenses	2,203 39	
Property	1,039 75	
State Board of Forestry, co-operative (gathering timber data)	724 16	
Underground water investigations	1,562 13	
Overpayment by Board of Control and refund on scrip book	28 48	
Total disbursements		54,788 66
		$45,211 34
By refund to Controller		28 48
Balance		$45,239 82

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Vouchers for all these expenditures, properly itemized and authenticated, are on file in the office of the State Board of Control.

Statement of moneys expended to November 1, 1912, and set aside under co-operative agreement, some of which is not yet expended.

		Expended.
Set aside under co-operative agreement with U. S. Geological Survey	$23,851 00	
Disbursed	14,615 27	$14,615 27
Balance	$9,235 73	
Set aside under co-operative agreement with U. S. Department of Agriculture	$21,150 00	
Disbursed	15,546 58	15,546 58
Balance	$5,603 42	
Fixed expenses (salaries and traveling expenses)	$15,887 50	
Disbursed	10,608 18	10,608 18
Balance	$5,279 32	
Operating expenses, office, etc.	$5,662 75	
Disbursed	3,696 53	3,696 53
Balance	$1,966 22	
Contingent expenses, gathering data, school lands, etc.	$10,000 00	
Disbursed	5,803 94	5,803 94
Balance	$4,196 06	
Commissioners' expenses	$2,825 00	
Disbursed	2,203 39	2,203 39
Balance	$621 61	
State Board of Forestry	$754 75	
Disbursed	724 16	724 16
Balance	$30 59	
Underground water investigations with U. S. Geological Survey (Lee)	$1,900 00	
Disbursed	1,562 13	1,562 13
Balance	$337 87	
		$54,760 18
Overpayment by Board of Control and refund on scrip books		28 48
Total disbursements		$54,788 66

Appropriation	$100,000 00	
Refund	28 48	
	$100,028 48	
Disbursements	54,788 66	
	$45,239 82	
Appropriation and refund	$100,028 48	
Set aside	89,881 00	
Balance unappropriated	$10,147 48	

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REPORT OF COMMISSION.

To the Governor and the Legislature of the State of California:

The task of the Conservation Commission has not been an easy one. It has had less than a year and a half in which to do the work laid out for it, which was to make, as well as may be, a survey of the natural resources of this State, as set forth in the act of the Legislature creating the Commission, collect data thereon, and to propose to the Legislature such laws, based on that data, as might appear practicable for the conservation of those natural resources.

One great difficulty with which the Commission has had to contend is the fact that the collection of the data necessary for the formulation of recommendations upon all the matters referred to it by the Legislature has, in all cases, required a long time, even when the Commission has availed itself, as it has in all cases where it has been possible, of the already organized forces of other departments of the state government and of the various departments of the Federal Government. In such matters as the flow of streams and the determining of underground water supply, it is at once evident that the data necessary for the formulating of recommendations by this Commission could not be gathered in the time at the disposal of the Commission with sufficient accuracy for the formulation of such recommendations. Such data must be gathered during all the seasons of the year, and, under conditions of varying annual rainfall, such as are characteristic of California, must be gathered during many successive years in order to be of the greatest possible value. The data gathered by the coöperating agents of the Commission and set forth in this report will, the Commission believes, prove of sufficient value to warrant the comparatively slight expense of their gathering.

COÖPERATIVE AGREEMENTS.

In surveying the field of its operations, the Conservation Commission came, at the very beginning, to the conclusion that it would be neither economical nor efficient for it to organize forces for the investigation of such matters as irrigation, the area and location of irrigable lands, and the gaging and examination of streams with regard thereto. It realized fully that the United States, through its Department of Agriculture, with its various bureaus, and the Department of the Interior, principally through the various branches of the Geological Survey, had regularly organized and equipped and trained persons engaged in exactly the work that this Commission contemplated doing. The Commission also realized that, were it to attempt to do the work already being done by these departments of the Federal Government, much time, money and effort would be wasted in duplicating work already in process under government supervision. Furthermore, the Commission realized that it could not do this work so cheaply or so well as the government is doing it; and that, for all these reasons, it would be best

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for the Commssion to coöperate with these trained government agencies in the collection of the required data. Upon consultation with Mr. Frank Adams, of the Irrigation Investigations, U. S. Department of Agriculture, and Messrs. M. O. Leighton, W. C. Mendenhall, J. C. Hoyt and H. D. McGlashan of the U. S. Geological Survey, the Government officials—Messrs. Fortier, True, George Otis Smith and others—very kindly consented to coöperate with this Commission, putting at our disposal their trained men and organizations, in return for the Commission paying the greater portion, but not all, of the expenses incurred in the work.

The results of this coöperation have been entirely satisfactory. The work has been rapidly done, and with far more efficiency and at far less expense to the State than would have been the case had the Commission attempted to do the work itself.

The texts of the coöperative agreements with the U. S. Departments of the Interior and Agruculture are set forth in this report in their proper places.

THEORY OF FREE GIFTS OF NATURAL RESOURCES.

It was the theory of our forefathers, who inaugurated the practice by which individuals have secured private property rights in natural resources, that such resources are of no good to the public unless they are used for the public benefit. This theory is, beyond question, correct. But those who put that theory into practice went a step farther. They reasoned that, in order to get these natural resources used for the benefit of the public, it would be necessary to allow them to become private property. That this theory is not correct is proven by the fact that other countries—most of them, in fact—succeed in getting their natural resources used for the benefit of the public without disposing of them and without permitting them to be monopolized or unnecessarily wasted or destroyed, as we have permitted most of ours to be. The result has been that these other and more farsighted countries have conserved their natural resources.

Our forefathers, proceeding on the theory that it was necessary to give our natural resources away in order to keep them from being unused, disposed of them with a free hand. The contrary result from that which they expected would follow has, in a great measure, resulted. Desiring to get these natural resources out of public ownership cold storage, they permitted them to be put into private cold storage, where they are used only somewhat more than they would have been used in public cold storage. The enormous, unused forests, in private cold storage in this State, and the enormous cold-storaging and nonuse of coal lands in private ownership in other parts of the country are cases in point.

Desiring to prevent the economic waste by nonuse, of the natural resources of this country, our forefathers gave them away. The result has been that most of these natural resources have been wasted and destroyed because of the desire of their private owners to get rich quick.

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The public has use, to be sure, but only a use limited by the very natural, human greed of those who are the public's successors in ownership of those natural resources. And, as a result of that very natural greed, the public is compelled to pay unnecessarily high prices for the limited use which it enjoys of the natural resources it once owned.

With this condition of affairs the Conservation Commission has no serious quarrel. Its members freely admit that, had they had the opportunity, they would, in the pursuit of quickly-acquired and enormous fortunes, also have wasted, destroyed, monopolized and cold-storaged any natural resources which might have fallen into their ownership. But the Commission, nevertheless, confidently asserts that the burden of the public would be none the less if its members, in common with others, had wasted, destroyed, monopolized, or cold-storaged such natural resources as they might have acquired.

True, in other countries which have not given away their natural resources there have not been such opportunities as there have been and still are in our country for the amassing, at the cost of the public, of enormous private fortunes in a few years by the monopolization, wasting, destruction, or even cold-storaging of their natural resources, as has been the case in our country. But the opinion seems to be quite prevalent, at least among those many millions of the American people, who, bearing the burdens caused by the giving away of the natural resources, do not correspondingly share in the benefits derived by the donee, that such fortunes are not balanced by corresponding public benefits.

Had our forefathers been able to foresee the bad economic results of coal, forest, water and other monopolies, wastes, destructions and cold-storagings resulting from their mistaken gifts of them, it is safe to say that the policy of giving our natural resources into private ownership would never have been followed, with the exception, perhaps, of the case of lands. This latter resource, being essential to the prevention of a land-owning aristocracy with all its attending evils, will be, everybody but the Socialists seems to think, better used for the public good if it is in the private ownership in small areas of those who, because of that ownership, will take care of it, and because of small areas can do so.

WATER THE ONLY NATURAL RESOURCE LEFT TO CALIFORNIA.

Water is practically the only natural resource left to the full regulation of the State of California. It is, equally with land and even more than the forests, of the greatest necessity for the prosperity and comfort of our people. Neither it nor its use ought to have been permitted to become, in any shape or manner, private property. With that portion of it, or the use of that portion of it, which has already been permitted to become private property, we have, at present, little to do, beyond so regulating the enjoyment of it by its present owners that it will be as little as possible provocative of public distress or inconvenience. But that portion of this natural resource which has not yet fallen into

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private control or ownership should not be permitted to do so. And that portion of it which is illegally privately-controlled or owned should be restored to public ownership and control. The only way, of course, in which that may be accomplished is by giving to some state agency the power to investigate conditions and initiate proceedings looking to their judicial restoration to the public.

THEORY AND PRACTICE OF CONSERVATION.

"Conservation of the natural resources" should consist, in the view of this Commission, not necessarily in the preservation of those resources, but in the use of them, in such quantities, under such conditions and at such times as the needs of the people require; without, however, any unnecessary waste or destruction, and without permitting them to become the subjects of monopolies detrimental to the public good.

There are natural resources which are absolutely necessary to the progress and prosperity of the public. Among them are conspicuously land, water, forests, coal, oil. Others, such as the precious metals, are of comparatively little value to the public from the standpoint of the conservationist, as they are of secondary importance to the actual, daily needs of the public.

Nobody would, the Conservation Commission believes, favor the monopoly of all the land in this State by a few score individuals. Such a monopoly always has led and always will lead to the division of a population into two classes—a small and very rich landlord class and a large and poor tenant and peasant class. The lands of the State of California have, very fortunately, been subdivided and are constantly being still more subdivided into smaller and still smaller holdings, so that the number of landowners, able to make livings from the products of their own lands, is rapidly increasing.

OWNERSHIP OF FORESTS.

But, as is shown by the table of landholdings in this report, 1,273 persons and corporations own over four and one half million acres of timber land in this State, over 4 per cent of the entire area of the whole State, or approximately 33 per cent of all the forests in the State, or practically all of the forests outside of United States reserves. Of these owners, two own over half a million acres each—one, the Southern Pacific, owning approximately 825,000 acres; the other, Mr. T. B. Walker, owning over 700,000 acres—an average of over 750,000 acres for each of these two proprietors. There are a little over 100,000,000 acres of land in this State. If 150 persons or corporations each owned 750,000 acres of land in California, all our territory—city and country, mountain, valley and desert—would be the property of that small fraction—about .00007 of 1 per cent—of our present two and a quarter millions of people.

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NONUSE OF FORESTS.

A great proportion of the enormous private holdings of forest lands in this State is not being used, but is being held, without cutting the timber, for the increased price of lumber which will come as the great mass of the forests disappear—as it is now fast disappearing. The result of this is that the public, which gave these forest lands away for little or nothing, is deprived of the present benefit of the use of a large portion of the natural forest resources of this State.

For this condition of affairs, the Conservation Commission has, of course, no direct remedy to offer. Such of the owners of this timber as are in lawful possession thereof cannot be deprived of it; and the Commission, in common with all law-abiding citizens, would not deprive them of their lawfully-acquired property, even if it could. And as the Commission has not been authorized to ascertain which, if any, of the owners of enormous tracts of timber lands are not in lawful possession thereof, we have no suggestions to offer with regard thereto.

DETERIORATION OF UNUSED FORESTS.

But we would call especial attention to the fact that, because some of these enormous timber holdings are not being used, they are deteriorating because of the decay of the ripe timber, and the public loses just that much of the benefits to be derived from the use of those forests. Furthermore, because the ripe timber in these "cold-storaged" forests is not being cut, immature timber in other holdings is being sacrificed to supply the demands of the lumber market, with the result that an economic waste in two directions—the loss by decay of the overripe timber and (the sacrifice of unripe timber) is being suffered by the public.

FOREST DETERIORATION BY FIRE.

There is also this to be considered: Some of the owners of these enormous tracts of timber lands are averse to spending the money necessary to preserve their timber from destruction by fire. They seem to argue that it is cheaper for them, if not for the public, not to spend the money necessary to protect this natural resource, so necessary to the public, from destruction by fire. Chief among the offenders in this regard seems to be the Southern Pacific. This corporation owns over 800,000 acres of forest lands in twelve counties in this State. It was given this land for nothing; yet it has consistently opposed the passage of any adequate forest-fire legislation in this State, preferring apparently to allow its forests to be in constant danger of destruction rather than to submit to any adequate legislation looking to their protection and conservation for the public good.

FEW NATURAL RESOURCES SUBJECT TO DIRECT STATE CONTROL.

At the very outset the Commission found itself confronted with the fact that the natural resources in California which may be directly controlled, regulated, and conserved by State law, are but few in

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number. The disposition of all minerals for instance is controlled by federal laws. Our forests originally were, with the exception of those standing on school lands, the property of the United States, which has disposed of the best portion of them and holds the remainder in national forests, national parks and other reservations. Lands, also, with the exception of the school lands given to the State by the United States, were reserved to the Federal Government by the act of Congress admitting California as a state, and have been disposed of to private individuals, with the exception of the lands retained by the Government in the reservations above mentioned. Even the State has sold, at ridiculously low prices, the lands given to it by the Government for the purpose of supplying funds for at least the partial support of our public schools.

NECESSITY OF CONSERVING PRIVATELY-OWNED RESOURCES.

The Commission, however, realizes that even in ownership other than that of the State, certain of our natural resources are so necessary for the present and future prosperity of the people of California, that the public must, in self-protection, take such measures as may be possible for their proper conservation. Our forests, for instance, are so absolutely necessary to the conservation, even the preservation, of our streams, springs and other sources of water supply for domestic use, navigation, irrigation, the generation of electrical and other power, that, even were they all in private ownership, it would be necessary for the public to put forth every effort to prevent the forests, while being used, from being exterminated.

PRIVATELY-OWNED FORESTS ALWAYS DESTROYED.

Private ownership of the forests, unregulated by close governmental supervision and regulation, has always led to their extermination. History abounds in instances where cities, provinces and countries, once densely populated and prosperous, have suffered greatly and have even become depopulated because they permitted their forests to be destroyed, with the result that the streams, upon which they depended for the fertility of their lands, became torrents in the winter and dry beds of sand in the summer.

CALIFORNIA BEGINNING TO SUFFER.

California, young as it is, begins already to show signs of the damage that always follows the destruction of the forests. The upper reaches of some of our rivers, that have been more or less stripped of the forest protection of their water sheds, already show greater ranges between their highest and their lowest stages than they did before they lost their forest protection; and their beds are filling, more rapidly than before, with the silt torn by the unrestrained water, furnished by the rains and melting snows, from the uncovered soil.

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NECESSITY FOR CONTINUOUS WATER SUPPLY.

For domestic purposes, navigation, irrigation, the development of power, and for all other uses, it is best, if not absolutely necessary, that the water supply of springs and streams shall be, as near as may be, uniform throughout the year—that there shall be small winter floods and large summer flows. But the destruction of the forests leads always to increased winter floods and decreased summer flows. In fact, forest destruction has reduced to zero the summer flow of many streams, which, before their protecting forests were destroyed, ran large all the year through. And such streams, deprived of their forests, do costly damage to property and even life by their winter floods, where, before the forests were destroyed, their flood stages did little or no damage.

DUTY OF STATE TO CONSERVE FORESTS.

It is evident, therefore, that it is the duty of the State to see to it that our forests, even such of them as are in private ownership, shall not be exterminated. Other countries than ours have long recognized the necessity for the conservation of their forests. Germany, during the last several hundred years, has, by government ownership or strict government regulation, conserved her forests. France has also done good work along this line. Other European countries have done likewise. And certain states of this Union, like New York, Maine, Wisconsin, Michigan and others, have begun to buy back, at high prices, forests, and even deforested lands that they gave away. The Federal Government, after having given away the vastly greater part of its forests, has within the last few years begun to realize the dangers of the situation, and has reserved from further spoliation and destruction large areas of forests on the headwaters of many of our streams.

INTEREST OF STATE IN PRIVATELY-OWNED FORESTS.

It is claimed that neither the State nor the Federal Government, having disposed of the forests, has any further interest in them. This would be so were it not that the forests are just as necessary to the public good in private as in public ownership; that their destruction entails just as much injury upon the public whether they be destroyed in private or in public ownership; and that the private owners of forests can make the most money in the shortest time by destroying them while lumbering them. As is shown further on hereunder, the State of New York has spent, on the recommendation of several of its Governors, several million dollars to buy back forests that it gave away for practically nothing. Even California spent $250,000 to buy for a public park, a redwood forest, which was originally given away by the public for comparatively nothing.

The Conservation Commission does not suggest or recommend that this State shall at this time spend any large sums of money for the acquisition of forest lands. But, as will appear later on in this report, it does recommend that the State acquire, or take temporary control

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of, large areas of cut-over lands for the purpose of initiating the reforestation thereof.

Furthermore, the State, by the exercise of its police power, can and ought to adopt such regulatory measures as will prevent, so far as may be possible, the unnecessary destruction and extermination of even the privately owned forests, either by reckless lumbering operations or by fire.

A partial discussion of the police power of the State, in regard to the regulation of privately owned forests, appears later on in this report.

WATER, FORESTS, LANDS MOST NECESSARY.

Under all the conditions that have confronted it, the Conservation Commission has been compelled to give its attention principally to the matter of the conservation of forests and water, and the conservation and even creation of soil fertility, and electrical and other power, dependent on the conservation of water. Water and forests, the Commission considers, are the most important natural resources now at the disposal of our people; and immediate attention to their conservation is required to prevent, as much as may be, the hurtful monopoly of the one and the unnecessary destruction of the other.

RESULTS OF DESTRUCTION OF NATURAL RESOURCES.

It was supposed, when the individual was given the right freely to appropriate our natural resources, that they were unlimited and inexhaustible in quantity. Less than half a century ago, for instance, it was commonly held that the redwood forests of California were of such enormous extent that they could never be all cut down; whereas, we now know that, even at the present rate of their destruction, there are people now alive whose only hope of seeing a redwood forest will lie in a visit to a public park. It was also claimed, a comparatively few years ago, that the nation's coal supply was inexhaustible. Mr. Andrew Carnegie, addressing the Conference of Governors, held in the White House in 1908, said: "When the Republic was founded, there were, according to recent expert estimates, approximately 2,000,000,000,000 tons of coal in the territory now forming the United States. Practically none of this supply was used for over a quarter century; but during the seventy-five years from 1820 to 1895 nearly 4,000,000,000 tons were mined by methods so wasteful that some 6,000,000,000 tons were either destroyed or allowed to remain in the ground forever inaccessible. During the ten years from 1896 to 1906 as much coal was produced as during the preceding seventy-five years; while more than 3,000,000,000 tons were destroyed or left in the ground beyond reach of future use. To date the actual consumption of coal has been over 7,500,000,000 tons; the waste and destruction in the neighborhood of 9,000,000,000 tons." . . . "In 1907 the production of coal was about 450,000,000 tons. At the present rate of increase the production in 1917 will be 900,000,000 tons; in 1927, 1,800,000,000 tons; and in 1937, over 3,700,000,000 tons—or an amount in that year alone equal to the pro-

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duction of the seventy-five years ending in 1895. And with continuation of the wasteful methods of mining, the consumption and destruction together during that one year would equal our total useful production up to the present date."

RESULT OF UNREGULATED USE OF COAL.

The public having given the coal away and having made no provision to prevent either its waste or its monopolization, is suffering now because of the high prices it is compelled to pay for the use of property which was once its own. Charles R. Van Hise, President of the University of Wisconsin, said, at the Conference of Governors: "Eight important railway systems now exercise an absolute monopoly over hard-coal mining. . . . . Together they own more than nine tenths of the entire anthracite deposits of Pennsylvania, and about three fourths of the total production is mined by their subsidiary coal companies." At the same conference Mr. James J. Hill, President of the Northern Pacific Railroad, said: "The exhaustion of our coal supply is not in the indefinite future. The startling feature of our coal production is not so much the magnitude of the annual output as its rapid increase." And Mr. H. St. Clair Putnam assured the conference that, "If the production of anthracite coal is continued only at its present annual rate, the supply will be exhausted in sixty to seventy years."

The present generation of American citizens, therefore, is suffering financial burdens because public property, in the shape of coal, was practically given away by preceding generations without any strings on the deeds of gift.

RESULTS OF MONOPOLY OF NATURAL RESOURCES.

The monopoly of natural resources that are necessary to the public welfare always has led and always will lead to public hardships. In England and other European countries, for instance, the monopoly of land has been a very great determining factor in the division of the people into two classes—one class, very small in number, exceedingly rich; another class, very large in number, exceedingly poor. Early in the history of this nation public lands were disposed of in enormous areas to private parties—and a land-owning aristocracy of wealth was created. It soon, however, became apparent that such a condition did not comport with a democratic republic. The people, therefore, demanded and the government inaugurated a system of land disposals which sought to prevent the acquisition of the public lands in large quantities by individuals. It was the theory of the law that no man should be given more than 320 acres of the public lands, and that that land, once disposed of in such modest holdings, would continue to be so held.

U. S. GOVERNMENT FEARED MONOPOLY.

It was a like fear of timber monopoly that caused the United States Government to dispose of its timber lands in parcels not greater than 160 acres and only one such parcel to any one individual. Even in

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the giving of land-grant aids to some of the railroads the same idea was apparent; for some of the acts of Congress making these grants contained a provision that the granted lands should be disposed of to "actual settlers" for not more than two dollars and a half per acre, and in parcels not greater than 160 acres. However, the observance of these conditions of the acts have not always been observed by the recipients of the benefactions of the people. The Southern Pacific, for instance, has sold some of its granted lands in parcels greater than 160 acres and for more than two dollars and a half per acre; and it has refused to sell such lands to all would-be actual settlers.

In the sale or disposition of its coal lands, its desert lands and mineral lands, the Government, with the idea of preventing monopoly, has refused to part with them in large areas. Of course, though, individuals once having obtained ownership, were permitted to part with that ownership on any terms that pleased them. The result has been that enormous frauds have been perpetrated on the Government in land matters; and that, honestly or dishonestly, enormous quantities of timber, coal and other lands have fallen into monopolistic private ownership.

RESULTS OF COAL MONOPOLY.

The results of such monopolies have been apparent especially in the matter of coal and timber lands. Coal, so necessary to the public and given away by the public, has been used to extort from the public enormous sums of money, even at the expense of great privation and suffering by an appreciable percentage of the public. Even California knows what it is to be in the hands of a coal trust. There are large quantities of coal in Washington, Utah, Wyoming, New Mexico; but because the public gave that coal away, the people have been deprived of the cheap use of it. For those to whom the public gave that coal, have, very naturally and very humanly, preferred to allow some of their coal to remain unworked and unused, so that, by starving the coal market, the price of coal might be kept at as high prices as the necessities of the people would compel them to pay for it.

Had the public seen to it that its coal was not given away into private ownership, the exactions and extortions of the various coal trusts of this country, and great deprivation and suffering, could have been prevented.

WATER POWER MONOPOLY FAR REACHING.

There is no large quantity of coal, but there are many mountain streams, in this State. And from these streams is already being produced, instead of from steam, the power that supplies the place of a very large portion of the coal and oil that otherwise would be used for fuel in the generation of power. As has been said in another part of this report, it is estimated that at least 5,000,000 horse power of electric energy may be developed from the mountain streams of California, equivalent to the steam power developed by burning 100,000,000 tons of coal per annum. And that power will, one day, be doing practically

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all the work that can be done by steam power; and being also used for lighting, heating and power purposes in every household in this State, it will be a prime public necessity.

A monopoly, therefore, of the water power of this State would reach into every house, put under heavy tribute every person in the State, and add enormously to the burdens borne by every California industry, great or small.

MONOPOLY ALREADY FORMED.

That such monopolies are already in existence in this State goes without saying. The bond-selling prospectuses for several of our power companies make this plain. In one such prospectus, as an inducement to those contemplating buying its bonds, it is very broadly hinted that the company has a monopoly covering one third of the area of the State and over one half of its population. As an important basis for the bonds, the statement is also made that the company owns many unused valuable water rights. And the further alluring statement is made that, as the population and power needs of the State increase, the value of these, at present unused water rights will rapidly and greatly increase. It is therefore proposed to make that which the public gave away the basis for an ever-increasing tribute wrung from the necessities of the public.

NO STATE AGENCY TO RECOVER ILLEGAL APPROPRIATION.

It is true that these public service corporations can and will be regulated, after they are formed, by the California Railroad Commission. But there is no adequate power given to any part of the state government to investigate and, subject to an appeal to the courts, take away from these companies any water rights they may have illegally acquired. That power can, in practice, be exercised only by individuals. And the task of taking such matters into court, in the face of determined and long-drawn out opposition, is not one that will be welcomed by individuals. The task of defending the property of the State from illegal monopoly should be the task of the State; it should not be left to the individual.

STATE SHOULD KNOW WHAT RIGHTS ARE UNAPPROPRIATED.

Furthermore, the State, in welcoming the putting into use of her water rights, should be able to know what water rights are available for that use. It is therefore necessary that there should be some State-representing agent with the power to ascertain what water rights are legally still subject to the control of the State. To do that, it is required that that agent shall be able to know which water rights have been legally acquired and which have been illegally acquired. For the State, welcoming the development of power projects, should be able to present a legally clear and unobstructed field of operation for such development and be able reasonably to assure would-be investors that they have at their disposal certain water rights. The State does this, with reasonable certainty, in the case of land titles. It ought to do so

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with equally reasonable certainty in the case of the right to use of water, which is the property of the public.

WATER DISPLACES COAL AND OIL.

Falling water can supply the places of two natural power-producing resources, coal and oil, for power purposes. Transformed into electrical energy, the power of falling water can be made to do anything that fuels can do. And as it can be transported more easily, quickly and cheaply than fuels, and used simply by the turning of a switch, electrical energy will soon supplant fuels for all purposes, and can be supplied to localities inaccessible to coal or other fuels. But a past generation of Americans permitted the use of large quantities of falling water to become private property. Oil, coal and other fuel sources of power will, in a comparatively short time, become exhausted; they are already becoming and will steadily become, because of lessening quantities and monopolization, constantly higher in price. But the supply of falling water can never be exhausted until the sun refuses longer to pump it from the ocean or the force of gravitation ceases to cause it to run down hill. The only manner, therefore, in which this most valuable natural resource can be used to the detriment of the public, who own and cannot be deprived of the ownership of it, will be monopolization.

CALIFORNIA'S WATER POWERS.

Former Governor Pardee, addressing the White House Conference of Governors, said: "It has been estimated that the utilization of all the stream-power from Mt. Shasta to the Techachapi, a distance of over 500 miles, will produce 5,000,000 horsepower of electric energy, equivalent to 100,000,000 tons of coal per annum, costing at present prices over $1,000,000,000. The utilization of all this water power would therefore annually save $1,000,000,000 in cost of fuel, and produce $1,000,000,000 worth of new property. . . . . The streams from which power may be obtained have been, within the last few years, filed upon to that extent, under the lax laws of California, that the fear is expressed in many directions that the power has been already pretty well taken up. Many, if not most, of these filings are for speculative purposes only; others are for future development; but comparatively few of them are actually being used or are in process of preparation for utilization. The fear is prevalent that the acquisition of these water rights by private persons or corporations will lead to monopolies and over-capitalizations, and that these great and most important natural resources will not be at the cheap disposal of the public. In fact, already, by means of purchase, by bond and stock issues, as practiced by some of the railroad and industrial corporations, the electric power used in the various cities of Northern California has fallen very much into the hands of one corporation, which, it is claimed, is greatly over-capitalized. . . . . Bearing in mind the results of railroad monopoly by means of consolidations brought about by similar means, it is not difficult to foretell the results of similar monopolization of the power of the streams of California."

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Former Governor Hughes, of New York, now Justice of the U. S. Supreme Court, in his 1907 message to the Legislature, said: "It is well to consider the great value of the undeveloped water powers. They should be preserved and held for the benefit of all the people, and should not be surrendered to private interests."

PUBLIC UTILITIES COMMISSION POWERLESS.

It is true that the California Railroad (Public Utilities) Commission can prevent the exactions of rates for electric power greater than are necessary to produce a fair income on the value of the property of an electric power company. But, if in the inventory of that property, there appears property in the shape of rights, given away for nothing by the public, to use the water belonging to the people, and if, in addition, as is the case, these property rights, already of enormous value, are rapidly increasing in value, it is evident that a public utilities commission cannot prevent the public being charged enormous sums of money for the utilization of the products of the use of its own property. If, however, the public had never permitted water rights to become private property, it is evident that the public could not be now assessed for the use of that which it gave away into private ownership.

There should be, therefore, the power lodged in some state agency to examine into water rights now claimed as private property and to initiate proceedings, where necessary, looking to the recovery to the public of those water rights which have not legally become private property.

WATER.

Of all the natural resources, there is none more valuable, more necessary to present and future generations of California than water. For domestic use, for navigation, for irrigation and for the generation of electrical power it is essential for the present and future prosperity of this State. From the mountain streams of California there may be developed, it is estimated, upward of 5,000,000 electrical horsepower. At present, the developed power from that source is in the neighborhood of 350,000 horsepower, with new developments constantly being made. Water-generated electricity runs our street cars, operates our mines, lights our streets and buildings, moves our machinery, pumps water for irrigation and other purposes, and is steadily being put to new and more extended uses. It is entirely safe to say that, within the next quarter of a century, electrical energy, developed by falling water, will be used for the commonest activities of everyday life. It will do most of the farmer's work; it will save the housewife much of her present drudgery; it will be necessary in every household and in every activity of our daily lives. It is estimated that 5,000,000 electrical hoursepower are equivalent to the steam power produced by the burning of 100,000,000 tons of coal per annum, worth, at present California prices, at least $1,000,000,000.

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The utilization of all of California's water power will save many millions of dollars annually to the people of this State. A monopoly, therefore, of our water-generated electrical power would put the power-requiring industries and the people of this State at its mercy.

WATER-POWER MONOPOLY FORMING.

Already such a state-wide monopoly is in process of formation. Already there are such monopolies in the northern and in the southern part of this State. Such attempted monopolies are, from the very nature of things, inevitable; because more money can be made by combination into larger companies of a number of smaller ones. But the public, of course, does not get its share of the benefits derived from such combinations, although the public has given, for nothing, the use of the water necessary for the profitable operations of these monopolies.

STATE CAN REGULATE MONOPOLIES.

It is true that the State can regulate such monopolies after they are formed. But the regulation will be all the more certain and satisfactory if the water by means of which the electrical power is developed is not permitted to fall unregulated into private control and the right to use it is not permitted to become private property. An ounce of monopoly-prevention is worth a pound of monopoly-cure.

It is also true that large amounts of electricity are generated in California by steam power, with oil and coal as fuel, and that much steam power, especially in railroad locomotives, is generated by means of oil fuel. But oil is not inexhaustible, and cannot be as cheaply produced or transported as electrical energy can be. For similar reasons and because of the coal monopoly coal is high in price. Therefore the price at which electrical power is sold in California is higher than it would be if the use of the water by which it is now generated had not been permitted to become private property.

OVER-CAPITALIZATION OF POWER COMPANIES.

There can be no doubt but that, based upon the private ownership of the right to use water, the capitalizations of many, if not all, of the quasi-public power companies of California have been enormously inflated or "watered," and that the public, from whom the right to use the electricity-generating water was obtained, is, therefore, compelled to pay higher prices for electrical power than would have obtained had the public not given away into private ownership the right to use that water.

PUBLIC OWNS WATER.

Under the organic law, the property right to water itself can not be taken away from the public. But California, from the very beginning of her existence as a State, has permitted the right to use water to become, by appropriation and later by riparian right, private property. The very natural result has been that appropriation rights

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have been capitalized, and the people, who gave away those rights for nothing, have been compelled to pay to private parties returns upon their ever-enhancing values.

"COLD STORAGING" OF WATER POWERS.

Not only that, but private parties have appropriated, for nothing, the right to use water and have not put that right to any use that is beneficial to the public. Those unused rights, if used, would be valuable to the public. Those who have obtained them consider them as valuable assets, and the public is compelled to pay returns upon those unused rights to use the water belonging to the public.

To illustrate: An electric power company appropriates, for nothing, the right to use a certain quantity of the water belonging to the people. In order to develop electrical power by the use of that water, the company expends a million dollars in pipe lines, dams, ditches, buildings, generating machinery and transmission lines. On that million dollars, the company should, as a matter of course, be permitted to collect even generous returns from the public who use the power generated and transmitted by the company's property. But the company, very naturally, considers that the monopolistic right to use that water, given away for nothing by the people, is valuable—worth, say, another million dollars. The company, therefore, proceeds to collect from the public returns upon two million dollars—one million of actual investment, another million represented by the used water right, which the public gave away for nothing. The public, therefore, is charged double rates for the product of the use of its own water, with the title to which water it never has parted and never can part. And this is not all; for if there be, as there generally are, other water rights which may be used in competition with those already appropriated and put to a beneficial use, the company very naturally proceeds to appropriate them and thus keep them from being used in competition with itself. These other monopolized water rights, given away for nothing by the public, the power company, very naturally, considers as valuable assets. It, therefore, demands that the public shall pay it returns upon that value. The public, therefore, is compelled to pay the company returns on, say, three millions of dollars—one million of actual investment, one million of monopolized, used water rights, one million of monopolized, unused water rights; although the public gave away both used and unused water rights for nothing.

It is true that the law of this State provides that no water right shall become private property unless the appropriator shall, within a certain specified time after he posts his notice of appropriation, commence work upon the project and prosecute the work diligently and uninterruptedly to completion. But nothing has prevented appropriators of the right to use water from holding appropriations, year after year, without doing much, if any, work upon them. Furthermore, as soon as one appropriation lapsed because of a failure to do any work upon it, the same appropriator was permitted to post and

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file a new notice of appropriation. Thus year after year, a very valuable public asset and natural resource could be, and often has been, kept in cold storage and monopolized without rendering the public, who gave it away for nothing, any benefit whatever.

Furthermore, claiming the right to divert and use water, a rich, and therefore powerful corporation could, without complying with any requirement of the law, scare off any other proposed appropriator by threatening to annoy and harass him in the courts, at great cost of time and money to the bona fide, would-be appropriator. In these ways it was formerly possible, and still is on old appropriations, for the appropriator of the use of water for power and other purposes to monopolize and cold-storage the most valuable, and constantly becoming more necessary, natural resources of this State.

CREATION OF WATER COMMISSION.

The last extra session of the Legislature passed a statute creating a State Water Commission, to which all applications for permission to appropriate the use of water for power purposes shall be made. The same act also limited to forty years the term for which the use of water can be appropriated for such purposes. It also declared to be unappropriated all water or the use of water which has not been put, with due diligence in proportion to the magnitude of the work, to a useful or beneficial purpose.

INADEQUACY OF LAW.

But the act did not give the Water Commission the power to investigate power and other appropriations and determine, with, of course, an appeal to the courts, which appropriations had been exercised in accordance with the provisions of the old law, and which had not been so exercised and, therefore, were null and void. The result has been that many appropriations of the right to use water, which were neither made in good faith nor prosecuted to completion as the law directed, are still being held in cold storage; and those who would, in good faith, reappropriate and put them to useful and beneficial purposes have been scared off from making new appropriations by fear of costly, time-consuming litigation.

The Conservation Commission's bill, by which the method for the appropriation of the right to use water for all purposes is still further defined and rendered clearer, gives the Water Commission the authority to investigate power and other water appropriations made prior to 1911, and to declare, subject of course to appeal to the courts, which appropriations have been and which have not been made and pursued in accordance with the provisions of the old law, under which the appropriations were attempted. The State should assume full control of its property and see that it is, from the very beginning of its use, properly used, and that its use is permitted only to those who can and will use it with a due and full regard for the rights of its owners, the public.

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TITLES TO WATER RIGHTS SHOULD BE CLEARED UP.

If the water rights of this State are to be finally, expeditiously and economically cleared up and determined, some agent of the State must be given the authority to go onto the streams, make the necessary investigations and declare, subject to court revision, what water rights are yet free for appropriation. Until that is done, no exact knowledge can be had of the amount of water open to appropriation.

Other states, notably Oregon, have adopted legislation similar to that proposed in the bill formulated by the Conservation Commission and now proposed to the Legislature, as the Act of 1911 directed the Commission to do. The Oregon law gives greater powers to the Oregon Commission than the Conservation Commission's bill proposes to confer upon the California Water Commission. But the Oregon Commission has made nearly 900 determinations as to water rights; and, according to its reports, less than half a dozen of those determinations have been appealed to the courts. The result has been that Oregon water rights have been confirmed upon bases which will render useless any further expensive and time-consuming legal contests concerning them.

The reason for assuming that the Oregon water rights are finally settled by the decisions of the Oregon Commission is that, first, no appeals have been made from the vast majority of those decisions; and, second, because as those decisions having been made as to and accepted by practically all the claimants on certain streams and stream systems, there is nobody left on those streams who has any interest in disturbing the present status. And the same conditions will naturally follow the Commission's work on other streams.

RESULTS OF CALIFORNIA WATER-RIGHTS LITIGATION.

In California, however, water litigation has never settled the rights of any persons other than those parties to each suit. If, therefore, there be one hundred water right claimants on any stream, the rights of each of those claimants can never be finally settled until each claimant sues every other claimant, or until, by some such procedure as the proposed bill provides, the rights of all the claimants are, without any great expense to the claimant, examined into and declared by a commission representing them all.

The right of appeal to the courts being reserved to each and every water-right claimant, the rights of every such claimant will be safeguarded as they are now. But, what is of equal or even greater importance, is that the rights may be speedily and economically adjusted and determined—which, under existing conditions, can not be the case until every claimant on each stream or stream system in California has sued, or has been sued by, every other claimant thereon.

As water rights in this State become more and more valuable—as they rapidly are becoming—the necessity for the speedy, economical and just determination of those rights becomes constantly greater,

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and in an increasing ratio. Millions of dollars have been spent in water litigation in this State, without settling the rights of anybody except those directly party to the litigation, and then only as between themselves. Many more millions will be spent, in litigation between individuals, without finally settling the rights of each claimant on a stream with regard to all other claimants on that stream, unless and until the State authorizes and empowers somebody to represent all the claimants.

The general public has direct and vital interest in the prosperity of the individual citizen. The general public suffers directly and indirectly when the money, energy, time and hopes of any of its citizens are dissipated in long-drawn out and expensive litigation. The general public and all water claimants have the right to demand that the rights to the use of the property of the public shall be speedily, economically and justly settled and determined. This, as the experience in Oregon has shown, will, the Conservation Commission is convinced, be brought about by the passage of the bill herewith proposed to the Legislature.

OBJECTION TO BILL.

It has been objected to this proposed bill that, because it gives judicial powers to the Water Commission, it is unconstitutional. The Commission, having taken the advice of eminent legal counsel in this regard, believes that the powers proposed to be conferred upon the Water Commission are not judicial, but merely administrative. And in support of its contention the Commission calls attention to the decision of the District Court of the United States for the District of Oregon in the matter of the determination of the relative rights to the waters of the Silvies River and its tributaries, in which the court declares that the Oregon Commission, whose powers are similar to, but greater than, those proposed to be conferred upon the California Commission, are not judicial but administrative.

NO MONOPOLY CREATED BY PROPOSED BILL.

It has also been objected to the bill proposed by this Commission for the regulation of appropriations of water, that it will create, instead of prevent, a power monopoly in this State, because it puts certain conditions and burdens upon power companies incorporated under it which are not borne by such corporations which came into existence under the old law. It is claimed that the fact that, under the proposed law, no power company can gain private ownership of water rights, will enable the old companies to monopolize the field, because they acquired, under the old law, private property rights in the water rights which they are using and enjoying.

The present law provides that no private property rights in water rights for power purposes shall be acquired. And it was quite vociferously asserted, when the bill was being considered by the Legislature two years ago, that its adoption would strike the death knell of power development in this State, and that no further appropriations of water

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for power purposes would be made under such a law. These prophets of evil were wrong in their prophecies. For, in the year and a half during which the State Water Commission has been in existence, 66 applications for permits to appropriate water have been made to the Board of Control (Water Power) and its successor, the Water Commission, and 14 permits for such purposes have been granted by the Commission. The total expenditures proposed under these approved 14 applications is $6,125,325, and the horsepower to be developed will be 132,648.

It was also strenuously objected to the passage of the act of 1911 that it would act as a deterrent to applications being made by poor men for the right to appropriate the use of water for power purposes. A glance at the report of the Water Commission will at once show that this prophecy, like the former, was a false one, for some of the applications made and the permits granted were for projects requiring the expenditures of small sums of money.

As for the present law or the proposed bill assuring to the old power companies a monopoly of the power markets in this State, the exact opposite is now under the present law and will be the result of the passage of the proposed bill, for such monopolies require the control of the water-right sources of power. And if, as under the old law—all arguments and assertions to the contrary notwithstanding—existing power companies could, by force of legal arms, by threatened law suits, by legal, extra-legal and illegal means, control, with or without using, those water rights which were required by would-be competitors, then they could, as a matter of course, monopolize between them the power markets of this State. And by dividing territory or by directly combining, the old and established power companies could have kept out of the State all competitors.

Under the present law, however, it is rendered impossible for the established companies to appropriate and put into cold storage any water which they had not appropriated and cold-storaged prior to the going into effect of the present law. When, therefore, any person or corporation desires to appropriate water under the present law he has at his disposal all those water rights—and there are many of them—which have not been appropriated and cold-storaged by the old companies, but which, under the old law, could have been appropriated and cold-storaged ahead of the possibility of independent appropriation. The proposed law does not change the present law with regard to the manner in which appropriations of the use of water for power purposes may be made. It simply adds to the State Water Commission's powers the authority to make an inventory of the State's water-power property and to list, so to speak, the appropriated and unappropriated water rights; so that every would-be appropriator may know what rights are unappropriated, and that the Water Commission may know whether or not there is water for the use of any person applying to it for a permit therefor. The proposed bill goes only a step further than the present law in rendering more

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certain the prevention of power monopoly at the fountainhead, viz., the water powers on the streams of the State.

As for the contention that the prevention of the acquisition of water rights as private property puts or will put the companies having such property in command of the power field in this State, this is conclusively to be said: The present law and the proposed bill provide that water appropriations may be made only for forty years. It is argued that, because they are not compelled to pay off their bonds in forty years, but can redeem the old ones with new issues, the old companies can, therefore, undersell new companies, which would be compelled to lay aside funds for the amortizing of their bonds at the expiration of the term of their license, viz., forty years. Those who make this assertion forget, however, that the old companies have capitalized, and capitalized very heavily, the property rights they have acquired in water rights, and made them the bases upon which enormous issues of stocks and bonds have been made. On these issues of stocks and bonds—these enormous "waterings" of capitalizations—the old companies must pay dividends and bond interest. The new companies are deprived of the power to capitalize as property the rights they have acquired to use the waters of the State—have been so deprived, because they can get no such property rights.

It is, therefore, apparent that the new companies, having no "water" in their capitalizations based upon property in water rights, being compelled to amortize their bonds at the expiration of forty years, will be no worse off, in the matter of charges for what they have to sell, than will be the old companies, which are compelled to charge enough, for what they have to sell, to pay dividends and bond interest on oceans of capitalization "water" based on the enormous and constantly-increasing values of their property rights in water rights.

Nor will the very small and insignificant charges made by the State under the present law, and continued in the proposed bill, serve, as the opponents of the present and the proposed law say it will, to give the old and heavily overcapitalized power companies, which do not have to pay such charges, any advantage over the new companies. These charges are so small that they can be and will be absorbed without adding any burdens to the consumers of power.

PRESENT DETERMINATION OF WATER RIGHTS.

As the California law now is, water rights have been determined, are now and will be determinable only by enormously costly and time-consuming suits between individuals, which settle, as has been said, only the rights as between those who are parties to each suit—leaving the rights as between those who are not parties to such suits undetermined and unsettled until finally determined and settled at the end of a long and costly series of suits.

The Conservation Commission, therefore, believes that it would be a distinctly advanced and very advantageous condition if there were given to the Water Commission, representing the public generally

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and every water claimant in particular, the authority to examine into and declare, subject to appeal to the courts, the rights of the claimants on the streams of this State to the use of the water belonging to the public.

ANOTHER OBJECTION TO BILL.

Certain individuals and interests oppose the proposed bill, asserting that it would increase, instead of decrease, litigation as to power rights.

In reply to that assertion, the Conservation Commission points to the following facts and considerations: Water rights in this State are rapidly becoming more valuable. The more valuable such rights become, the greater is the temptation, even the necessity, to indulge in costly litigation concerning them. As the law now is only the rights of those who have entered into litigation are settled, and then only as between the parties to each separate suit. There is possible no general settlement of rights on any stream, unless each individual claimant sues every other individual claiming rights on that stream. Under such conditions it lies in the power of individuals to keep water claimants involved in litigation indefinitely.

But if, as has happened in Oregon, the State gives the Water Commission authority to investigate and declare the rights of all claimants upon a stream, with, of course, an appeal to the courts, then, as has happened in Oregon, the interrelated rights of all claimants on a stream may be finally, speedily and inexpensively determined. And, unless some claimant is dissatisfied with the decision of the Commission, there will be no further litigation in regard to those rights—as has been the case in Oregon.

In Oregon, of 865 cases in which water rights were determined by the State Water Commission, only some three or four have been appealed to the courts.

Furthermore, the proposed bill provides that it shall be discretionary with the Water Commission whether or not it shall investigate and determine the rights of water claimants on any stream, even if demands shall be made that it shall so investigate and determine. It is, under the provisions of the bill, for the Commission to determine whether or not the public good will be subserved by the making of such investigation and determination. This provision of the bill, the Conservation Commission feels sure, will further tend to restrict water litigation in this State.

As the proposed bill recognizes "vested and existing rights" it will, instead of promoting litigation, the Conservation Commission believes, practically prevent further water litigation in this State, as the decisions of the Oregon Commission have practically done away with water litigation in that State.

WATER RIGHT TITLES SHOULD BE SETTLED.

The titles to water rights in this State should be as finally established and determined as are the titles to real estate. The titles to our real estate date back to and are determined by the soundness or unsoundness

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of the titles of the original private owner thereof. Those original titles were judicially determined long ago. But there never had been any method, and there is no method now, by which the titles to the use of water can be quickly, inexpensively and finally determined. Real estate would now be in the same condition if the title to it had not been determined by wholesale long ago. The owner of real estate gets title to a definite quantity of land; and the existing quantity of that land never varies. But the right to use water is hedged about with so many necessarily varying conditions of demand for a constantly varying amount thereof, that, until the right of every claimant, as compared with that of every other claimant, on each stream has been settled and determined, litigation over water rights will always be imminent and unavoidable.

Until water rights are determined from a wholesale standpoint, water right titles in California must remain unsettled and the possessors of the longest purses can indefinitely harass and annoy those whose purses are not so long.

RIPARIAN RIGHTS.

There is in this State a modified doctrine of riparian rights. Under such rights, proprietors of riparian lands are permitted to require that all the waters of a stream, on which their riparian lands are situated, shall flow to their riparian lands, excepting such waters as may have

Land flooded by waste water, near Los Banos, California.

been acquired, by five years prescriptive use, by appropriators, or have been used by superior riparian proprietors.

The result of this is that enormous quantities of water, which might be, and ought to be, put to some beneficial use are permitted to run to waste into the ocean without doing anybody any good, and in districts subject to flood doing great harm.

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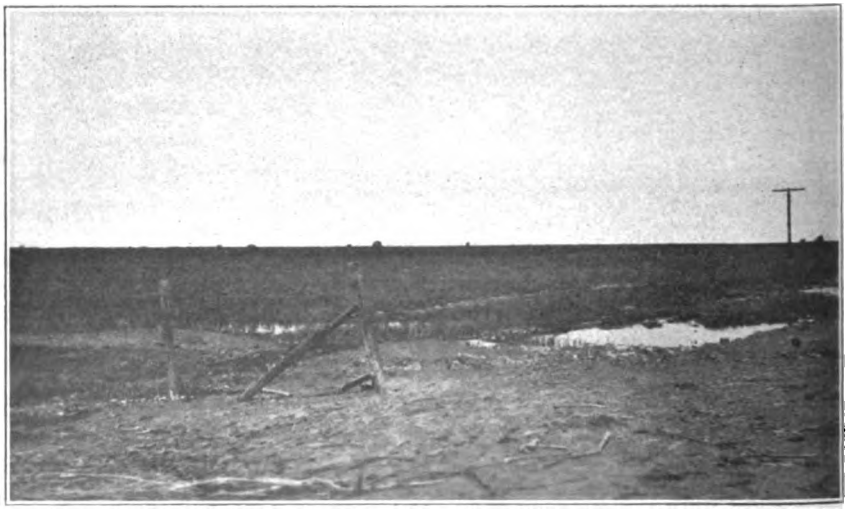
There are, therefore, in this State, on the one hand, hundreds of thousands of acres of semiarid and irrigable lands, and of overflow lands on the other hand, which, because of the wasteful exercise of the right of riparian proprietors cannot be cultivated and are, therefore, of comparatively little use to the people of California. The Conservation Commission and all others who desire to see the water resources of California developed and used for the benefit of the people, look with the greatest disapproval upon this right and privilege of the riparian proprietors to waste and turn into a devastating element a most valuable natural resource.

NATURAL RESOURCES SHOULD BE USED.

The Conservation Commission does not care who uses our natural resources, so long as they are used, not wasted, not destroyed, and not hurtfully monopolized. The Commission cares not who uses the waters of this State, the appropriator or the riparian proprietor, so long as they are put to a useful and beneficial purpose by somebody. If the riparian proprietor will not or cannot put to a beneficial use the water that flows down to his land, the Conservation Commission is firmly of the opinion that he should be compelled to permit somebody else to use it—he should not be permitted to let it go to waste and become a nuisance.



Land swamped by waste water from canals in and about Los Banos, Merced County.

MISUSE OF RIPARIAN RIGHTS.

Neither should the riparian proprietor be permitted to put all his riparian water to an entirely inferior and unnecessary use, to the exclusion of many others who, by appropriation, could put some of it to a far superior use. One large riparian proprietor for instance, in the San Joaquin Valley, floods his almost limitless cattle pastures with

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unnecessarily enormous quantities of water, and does not permit even the excess to be used on the irrigable lands of others, where its use would be of great value to those others and therefore to the State.

A tithe of that water put upon that riparian land would produce the same amount of grass, for cattle pasture, that the tremendously wasteful use of the water now produces. Because of such wasteful use of the water on those riparian lands, there are many thousands of acres of other semiarid, irrigable and fertile lands, which, because they can not be supplied with the excess water which the riparian proprietor allows to run to waste, are nowhere near so productive or valuable as they could be made to be if this wasted excess-water were allowed to be put upon them.

RIPARIAN DOCTRINE NOT APPLICABLE TO CALIFORNIA.

The riparian doctrine is not and never was applicable to the arid and semiarid lands of California. It is applicable only to such humid climates as that of England, where it originated, and where the streams, not being useful for irrigation, are used only for navigation, drainage, fisheries, domestic use, and other similar purposes.

RIPARIAN DOCTRINE NOT STATUTORY.

Neither was the riparian doctrine in this State the result of direct legislative action. It was made the law by the adoption of the common law, and is one of many similar instances where the courts have stepped outside of their prescribed rights and have invaded the rights and prerogatives of other departments of the government of the States and the Nation.

RIPARIAN RIGHTS VESTED.

The Conservation Commission endeavored to find some way by which the Legislature could compel the riparian proprietors of this State either to reduce their rights to use riparian waters to actual practical use or to permit someone else to do so—in other words, to cease wasting one of the most valuable natural resources of this State—so long as there is a pressing and clamorous demand for use of the excess water on lands other than those of the riparian proprietors. But the Commission was assured by eminent legal advisors that, as the Supreme Court had conferred riparian rights upon riparian proprietors, those rights were vested property rights of which the holders can not be deprived unless compensation be made therefor. There appears to be but one way in which these riparian proprietors may be compelled to part with their right to waste the waters of our streams—and that is by condemning those rights and making jury-determined compensation for them.

MODIFICATION OF RIPARIAN DOCTRINE.

Later decisions of the Supreme Court, however, seem to show a tendency on its part to modify its previous declaration to the effect that the rights of the riparian proprietors are higher and more sacred than those of any other class of our people. In an article in the *California*

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Law Review for November, 1912, Mr. S. C. Wiel quotes from the decision of the Supreme Court—*San Joaquin etc. Co.* vs. *Fresno Flume, etc. Co.*, 158 Cal. 626—as follows: "The fair apportionment and economic use of the waters of this State are of the utmost importance to its development and well being. The problems presented never came within the purview of the common law. They have been of necessity, therefore, and must continue to be solved by this court as cases of first impression, and as in the past, so in the future, if a rule or decision at common law shall be found unfitted to the radically changed conditions existing in this State, so that its application will work wrong and hardship rather than betterment and good, this court will refuse to approve and follow the doctrine."

Mr. Wiel also quotes from *Gallatin* vs. *Corning Irrigation Company*, 44 Cal. Dec. 169, as follows: "Storm or flood water in a stream does not pertain to the riparian right, if diversion thereof to distant lands will not impair riparian lands, and the ruling permits such diversion against any riparian opposition." And the court also says concerning decisions in preceding cases, that: "These decisions, in effect, establish the just rule that flood waters which are of no substantial benefit to the riparian owner or to his land, and are not used by him, may be taken at will by any person who can lawfully gain access to the stream, and conducted to lands not riparian, and even beyond the watershed, without the consent of the riparian owner and without compensation to him. They are not a part of the flow of the stream which constitutes 'parcel' of his land, within the meaning of the law of riparian rights."

It requires but a step more to be taken by the court for it to be held that riparian owners cannot forever either waste the normal flow of streams or prevent that portion of it which they cannot or will not themselves use from being used by other parties.

The Conservation Commission regards it as extremely unfortunate for California, that any person should have it in his power to demand and require that so valuable a natural resource as water, which is so necessary to the immediate and future advancement and prosperity of this State, should be permitted to run to waste because of the court-conferred right to permit such waste.

STATE MIGHT CONDEMN RIPARIAN RIGHTS.

The Conservation Commission is of the opinion that the State of California could well afford to condemn and, if necessary, pay for these riparian rights and permit the water, thus made available for highly beneficial uses, to be appropriated and put upon the many thousands of acres of fertile lands where it is now so much needed. In the opinion of the Commission, the State, having through its agent, the Supreme Court, given to riparian proprietors these rights, the State could well afford to take them back and compensate their present owners for them. The result of such action on the part of the State

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would be the creation of a vast amount of new wealth and a greater prosperity for millions of present and future California citizens.

UNDERGROUND WATER.

Underground waters are, in California, of very great value for irrigation purposes, especially in those large sections of the State where irrigation from streams is not easy or cheap. From this underground source much irrigation water is being drawn and still more will, in steadily increasing amounts, be drawn. In the San Joaquin and Sacramento valleys and, especially, in southern California is the subject of underground water receiving attention. The subject-matter is, however, so vast that the Conservation Commission felt that it had neither the time nor the funds necessary to make a satisfactory investigation of it. The question of replenishing, by artificial means, underground water supplies, so that they might furnish greater amounts of water for irrigation, seemed to be within the ability of the Commission for investigation. It, therefore, secured the services of Mr. Charles H. Lee, of the U. S. Geological Survey, to examine and report on the results obtained from such an artificial replenishing of underground waters in the San Bernardino Valley where the winter floods of at least one stream are thus stored. Previous to this artificial, subterranean storage of the waters of this stream, its winter floods not only ran to waste into the ocean, but also did more or less damage. It is practically certain that there are other large areas of this State in which similar artificial, subterranean storage of water for irrigation purposes may be made. Mr. Lee's report will be found attached hereto.

APPROPRIATION OF UNDERGROUND WATERS.

There being no statute law in this State regulating the right to appropriate and use underground waters, such rights have been so far regulated only by court decree. Such method of regulation, the Conservation Commission believes, is not the best method. It should be by well considered statute laws. The Commission does not hesitate to predict that, as the rights to the use of surface waters have been the subject of long continued and very costly litigation in this State, because of the absence of proper statutory regulation of such rights, so, in the absence of proper statute law concerning it, the rights to appropriate and use underground water will be the subject of constantly increasing litigation between those to whom it is becoming, with constantly increasing rapidity, more necessary, and, therefore, more valuable.

CAREY ACT.

There are in this State large areas of semiarid lands that can be irrigated and made highly productive by irrigation. A superficial investigation has led the Conservation Commission to the belief that, under the provisions of the Carey Act of Congress, large areas of this State may be transformed from deserts or practically deserts into most highly productive farms. The provisions of the Carey Act are as follows:

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TEXT OF CAREY ACT.

"That to aid the public land States in the reclamation of the desert lands therein, and the settlement, cultivation and sale thereof in small tracts to actual settlers, the Secretary of the Interior with the approval of the President, be, and hereby is, authorized and empowered, upon proper application of the state to contract and agree, from time to time, in each of the states in which there may be situated desert lands as defined by the act entitled "An act to provide for the sale of desert land in certain states and territories," approved March third, eighteen hundred and seventy-seven, and the act amendatory thereof, approved March third, eighteen hundred and ninety-one, binding the United States to donate, grant and patent to the State free of cost for survey or price such desert lands, not exceeding one million acres in each state, as the state may cause to be irrigated, reclaimed, occupied, and not less than twenty acres of each one hundred and sixty-acre tract cultivated by actual settlers, within ten years next after the passage of this act, as thoroughly as is required of citizens who may enter under the said desert land law.

Before the application of any state is allowed or any contract or agreement is executed or any segregation of any of the land from the public domain is ordered by the Secretary of the Interior, the state shall file a map of the said land proposed to be irrigated which shall exhibit a plan showing the mode of the contemplated irrigation and which plan shall be sufficient to thoroughly irrigate and reclaim said land and prepare it to raise ordinary agricultural crops and shall also show the source of the water to be used for irrigation and reclamation and the Secretary of the Interior may make necessary regulations for the reservation of the lands applied for by the states to date from the date of the filing of the map and plan of irrigation, but such reservation shall be of no force whatever if such map and plan of irrigation shall not be approved. That any state contracting under this section is hereby authorized to make all necessary contracts to cause the said lands to be reclaimed, and to induce their settlement and cultivation in accordance with and subject to the provisions of this section; but the state shall not be authorized to lease any of said lands or to use or dispose of the same in any way whatever, except to secure their reclamation, cultivation and settlement.

As fast as any state may furnish satisfactory proof according to such rules and regulations as may be prescribed by the Secretary of the Interior, that any of said lands are irrigated, reclaimed and occupied by actual settlers, patents shall be issued to the state or its assigns for said lands so reclaimed and settled: *Provided*, That said states shall not sell or dispose of more than one hundred and sixty acres of said lands to any one person, and any surplus of money derived by any state from the sale of said lands in excess of the cost of their reclamation, shall be held as a trust fund for and be applied to the reclamation of other desert lands in such state. That to enable the Secretary of the Interior to examine any of the lands that may be selected under the provisions of this section, there is hereby appropriated out of any moneys in the treasury, not otherwise appropriated, one thousand dollars."

ALL WATER RIGHTS SHOULD BE REGULATED BY THE STATE.

Water for all purposes, irrigation as well as power, is rapidly becoming more necessary to the proper and full development and habitability of this State. The State, therefore, is vitally interested in seeing to it that the old slipshod and unsatisfactory methods, under which any person could appropriate and put or not put the waters of the State to beneficial use, shall be displaced by a more satisfactory and determinative method for the regulation and control of water appropriations. The appropriation of water for power purposes has already been put under State regulation, and the would-be appropriator must submit his proposal to appropriate to the Water Commission—he is no longer permitted to initiate such appropriations simply by posting and recording a notice—he is no longer permitted to file one appropriation on another far beyond the capacity of the stream to furnish the water even previously appropriated. There is now a State authority to see to it

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that appropriations for power purposes are made in good faith and carried out in good faith; and that, when good faith in either particular is wanting, the attempted appropriation is voided and annulled. But there is no power lodged in any State agent to clear out of the way appropriations for power purposes made under the old law and not carried on with the good faith required by that old law.

Appropriations of water for power purposes are, however, of no greater importance to this State than are appropriations for irrigation purposes. With regard to irrigation appropriations the old law still prevails. Any person may post and record his notice for new irrigation appropriations, whether or not there is enough unappropriated water in the stream to satisfy even previously made appropriations. And having, in this slipshod and faulty manner, made his appropriation, the

Overflow water from ditch near Los Banos, Merced County.

appropriator must, even if he be in good faith, find out for himself whether or not there is, or will be, enough water in the stream, unclaimed by previous appropriators or riparian proprietors, to satisfy his needs. If, on the other hand, such an appropriator be not in good faith, he can, under the law as it now is, make his irrigation appropriation and sit down upon it, until, at great expense of time and money, he shall be dispossessed of it by some private individual.

"CAVEAT EMPTOR" DOES NOT APPLY.

"Caveat emptor" may apply well where only individuals are the parties in interest. But the whole people of this State are vitally interested in seeing to it that no appropriative water monopolies are created, and that any unused portion of this invaluable natural resource shall be at the disposal of those who, in good faith, desire to appropriate and use it. The State should allow none of it to be held unused in cold storage.

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STATE AGENCY NECESSARY.

The monopoly of irrigation water is not so easily accomplished as water monopoly for power purposes. But water for irrigation is necessary for the rapid population of a very great portion of the State. And, as the population of any portion of the State grows more dense, the need of water for irrigation purposes grows more intense and its value, therefore, always greater. It is necessary, therefore, that in the case of water for irrigation, as well as power, purposes, there should be some agency of the State to which would-be appropriators of water for irrigation purposes must apply, in order that there may not be confusion worse confounded in the matter of these appropriations. That State agency should also have the authority to examine and investigate the appropriations that have already been made, and, subject, of course, to court determination, find out what appropriations have been made in compliance with the law. In this way, and in this way only, can the titles to water rights be cleared up and long-drawn out and enormously expensive litigation over irrigation water rights be avoided. The litigation, costing millions of dollars, and, in not a few cases, stopping for many years the development of large sections of this State could have been avoided had the State had some agent through whom the steps preliminary to the actual putting to use of water should have been referred.

SETTLED WATER RIGHTS NOT DISTURBED.

In those portions of this State where the rights to the use of water have been finally determined and accepted by everybody, there is no crying necessity for the exercise of any State supervision in the matter of the rights already finally determined and universally accepted. And in such cases no State agency could or ought to interfere. But these final determinations of water rights have been made only after long and expensive litigation by individuals. Appropriators in those portions of this State where water rights have not yet been finally determined and accepted should not be put to the same private expense for the purpose of determining water rights. For their purposes, if for none other, the State should have an agency to which would-be irrigation appropriators should apply, and to which the power has been delegated to examine into, where necessary, the bona fides of appropriations already made or attempted.

STATE SHOULD KNOW HOW MUCH WATER UNAPPROPRIATED.

Before the State should attempt to grant a right to appropriate and use any of its water property, it should know how much of that property, not being already put to a beneficial use, is appropriatable and may be put to other beneficial uses. Before the State can give a permit, that really means anything to the permittee, to use any of its water property it must know how much of that property it has at its disposal to grant under such permits. If the State has not such knowledge, its permits are of uncertain value, and the holders of them are compelled

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to take all the risk involved by other adverse possessory rights. It is, therefore, necessary for the State to know, not only what water has already been put to beneficial uses for power purposes, but also what waters have been appropriated for all other purposes. The present slipshod, haphazard method of appropriating water for irrigation purposes and the former slipshod and haphazard method of appropriations for power purposes have led to a condition of affairs where the last would-be appropriator, either for power or irrigation, must proceed to divert his water in the face of a possible lawsuit; or, having gotten his permit, finds that the permit is useless because all the water in that particular stream has already been appropriated; or, in order to protect himself, must buy off the holder of a shadowy, unperfected prior right to the use of water, which right, however, is of sufficient validity to support a law suit. All these troubles can be, ought to be, avoided if the State is to protect and regulate, as it should, the right to use its waters. It is, of course, impossible for the State to do that, unless it knows what valid appropriations and other rights are in existence.

LAND TITLES PROTECTED.

Real estate titles are protected by public records which are recognized by the courts and which give a minute history of the title to every parcel of land. There should be an agency of the State through which the titles to water rights may be at least equally well defined and settled; and the right to appropriate water, for any purpose should no longer be left to the desire, bona fide, speculative or otherwise, of the individual, expressed simply by the filing and recording of a notice, with no agency of the State whose business it is to supervise the transaction at any point.

"BULLETIN 100" ON NECESSITY FOR STATE REGULATION.

The unnecessary danger, inconvenience, law suits, expenses and other annoyances, some of them very serious in their results to individuals and even communities, resulting from the absence in this State of any central state agency with authority to initiate proceedings to straighten out existing water right tangles and to prevent others from being created, are well described and commented on in the famous and authoritative "Bulletin 100," issued by the U. S. Department of Agriculture, in 1901. This bulletin referred especially to California conditions, and was written and compiled under the direction of the following well-known Californians: Professor C. D. Marx, then and now of Stanford University and the present chairman of the State Water Commission of California; Professor Frank Soule, then and now of the University of California; C. E. Grunsky, formerly a member of the Panama Canal Commission and the San Francisco Water Commission; Marsden Manson, formerly City Engineer of San Francisco and a member of its Water Commission; James D. Schuyler, the eminent hydraulic engineer, and Messrs. James M. Wilson, Edward M. Boggs, and William E. Smythe.

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QUOTATIONS FROM "BULLETIN 100."

Mr. Elwood Mead, the great irrigationist, formerly of the U. S. Department of Agriculture, now head of the Department of Irrigation of Australia, speaking of the necessity for State control of the waters of this State, in "Bulletin 100," page 54, said:

"California also needs a law which will stop all further claims to water where the entire supply is now appropriated. Every ditch which can not be filled, every pump which can not be operated, every acre of land prepared for irrigation which is in excess of what the stream will serve, means either a loss of the money invested or the robbing of an earlier user; sometimes it means both. So long as the right to make new appropriations is unrestricted, so long will old rights be insecure." * * *

"The advantages of public control which would restrict the construction of additional works until it had been demonstrated that there was water for their use and provide for a just division among the works already in existence seemed so obvious that I sought from those directly interested an explanation of why an attempt had not been made to secure it. The reply in every case was practically the same. All classes of water users and water claimants united in saying the state government did not offer any prospect of remedy and that they could not afford to take any chances but preferred to come to an agreement among themselves."

"It is not believed that this fear is well founded. It would take remarkably corrupt officials to create evils equal to those now existing. The notion that we must have human nature reformed and all the state machinery perfected before anything is done toward the regulation of streams is certainly erroneous. That any sort of system will remedy all these evils, or entirely avert controversies, is not expected. No matter how efficient a code of laws may be devised, or how honest and efficient their administration, there is certain to be friction because of the conflicting views created by the unfortunate absence of definite control in the past."

Speaking of the reports of Messrs. Grunsky, Smythe, Soule, and Judge Works, which show that water litigation, costing millions of dollars, have settled only the interrelated water rights of individuals, but have not settled the water rights of those not parties to the suits, Mr. Mead (page 61, "Bulletin 100") says:

"The showing made by these official records is referred to in order to make clear that the State has a duty toward these creators of wealth which it is not discharging so long as it leaves any of them in doubt as to what is their just share of the river's flow, and puts upon them the entire expense of securing that share. Appropriators of water ought not to be subjected to the expense of protecting their rights. That is a duty of the Government and should be paid for by public taxation. It is the only way in which impartial justice can be assured. Leaving the ownership of streams to be fought over in the courts and titles to water to be established in ordinary suits at law has never resulted in the creation of satisfactory conditions and never will. As it now is the same issues are tried over and over again. Each decision, instead of being a step toward final settlement, too often creates new issues which in turn have to be litigated. The suit of one canal company against another company may settle the rights of these parties as against each other, but it settles nothing with respect to other appropriators not made parties to the litigation and the whole controversy may be opened up at any moment. A stream with three appropriators has the foundation for at least three lawsuits: A *vs.* B, A *vs.* C, and B *vs.* C. If there are four appropriators the way is open for six adjudications. Often the appropriators of a stream are numbered by scores and even hundreds. It might be interesting to compute the number of legal conflicts necessary to a judicial determination of the relative rights on streams like the Yuba, and these will, under the present procedure, increase with the years because there will be new appropriations and old ones will be extended. It is not surprising that the petition for this investigation should state that the litigation is appalling. It could not be otherwise. Litigation is as natural a product of the absence of public control as are weeds in a neglected field."

"There can be no stability under the present situation. The law affords no means of enforcing a right when once adjudicated except through another lawsuit. Irrigators can not live in peace. Litigation and controversy are forced upon them.

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To acquiesce in a new diversion, through sympathy, or for the sake of peace, may lay the foundation for an adverse right by prescription and end in the curtailment or the overthrow of all the rights of the peace lover. This uncertainty and the fear of being supplanted which grows out of it is the cause of much of the hostility with which appropriators regard new ditches, and is the motive behind much of the extravagance and waste which sometimes prevail in the use of water. With a right clearly defined and protected, its owner has no fear of shortage in time of need, and he is willing, when his crops do not require water, to have it utilized by others. But when the right is insecure or not defined the instinct of self-protection makes an Ishmaelite of every water user. His hand must be against every man, as every man's hand is against him. Duty to himself and to those dependent on him makes it necessary that he shall use all means at his command to discourage the establishment of rights which may later interfere with his necessary use of water. Under such a system every new appropriator is a new element of uncertainty and another menace to the peace of the community. The whole system is wrong. It is wrong in principle as well as faulty in procedure. It assumes that the establishment of titles to the snows on the mountains and the rains falling on the public land and the waters collected in the lakes and rivers, on the use of which the development of the state must in a great measure depend, is a private matter. It ignores public interests in a resource upon which the enduring prosperity of communities must rest It is like A suing B for control of property which belongs to C. Many able attorneys hold that these decreed rights will in time be held invalid, because when they were established the public, the real owner of the water, never had its day in court." * * * *

"Under a rational irrigation code titles to water are established like titles to public land, by proceedings which are wholly ministerial. This is the case under the Northwest irrigation act of Canada, and under the Wyoming irrigation law, where the supreme court recently held that even in determining territorial rights the state board of control acts as an administrative and not as a judicial body. (*Farm Investment Co.* vs. *Carpenter*, 61 Pac. Rep. 258.)"

"If the amount of an appropriation depends upon the volume of water beneficially used, the first step in the determination of a water right should be a physical investigation. The water supply should be measured, the capacity of the ditch which diverts it should be determined, and the area and location of the land on which the water has been used defined. With these facts before it, the tribunal which fixes the amount of a water right has only a problem in mathematics. The judicial element is no more present than it is in fixing the taxable value of a horse or cow, in passing upon an assessment schedule, or determining whether or not a homesteader has complied with the land law. Determining the amount of water used is no more a judicial act than the fixing of a tax rate by a board of supervisors, the leasing value of land by a board of land commissioners, or hundreds of other acts of official and everyday life which require the exercise of ordinary judgment and discretion. One of the most mistaken and injurious beliefs is that rights to water can be settled only through a lawsuit. Nevertheless, the opinion seems to prevail widely, not alone in California but throughout the arid region, that water is a kind of property which must be disposed of exclusively by the courts."

PRESENT WATER TITLES NOT ABSOLUTELY SURE.

Especial attention is called to that sentence of Mr. Mead's report, in which he says: "Many able attorneys hold that these decreed rights will in time be held invalid, because when they were established the public, the real owner of the water, never had its day in court." In other words, the people of California own the water of this State. If, then, A sues B for the settlement of a water right and gets a judgment confirming to him the right to use a certain amount of water, that judgment confers title to A only as regards B, but has no binding force with regard to C, D, E, or F, none of whom was party to the suit or had his day in court with regard thereto. So C, D, E, and F can each sue A, and be sued by each other. But, in none of the suits for the settlement of water rights in California has the public, the real owner

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of the water, been made a party, or had its day in court. So, after A, B, C, D, E, and F have each sued, and been sued by, the other, and have received judgment, or have divided, by agreement among themselves, the waters of a stream, the public, the real owner of the water, against whom the statute of limitations does not run, may step in and, suing them all, take from them their costly litigated water rights, on the ground that it, the real owner, never having had its day in court, is not bound by any of the preceding litigation, to which it was not a party.

It, therefore, appears that, in order to assure their titles to water, all present users of it, as well as all those who may appropriate it, ought gladly to welcome the appearance of the State in the settlement, adjudication and determination of past, present and future water rights. The bill proposed herewith, following the general lines which have worked so well in other states, provides, in the State Water Commission, an administrative body through which the legal tangles of present water rights may be straightened out and future tangles prevented.

INVESTIGATION OF WATER LOCATIONS.

In September, 1911, in conjunction with the Board of Control (Water Power) the Commission began an investigation of all locations (under sections 1410 to 1422, C. C.) of water for power purposes. Agents were sent to every county in the State to make an abstract of the location notices. These abstracts, aggregating about 30,000 in number, are part of the records of the Water Commission. A card index to streams with a cross reference to the name of the appropriator has been prepared and is on file in the office of the Commission, so that any location notice may be easily found. Five graduate civil and hydroelectric engineers were employed by the State Water Commission to investigate conditions on certain streams, principally to determine the amount of development work performed by the locators of water rights under the old method of appropriation. These men examined about fifteen hundred appropriations situated in Plumas, Butte, Tehama, Shasta, Yuba, Sacramento, Yolo, Tuolumne, and Inyo counties. It is apparent from the investigations made and statements secured by the engineers from residents in the vicinity of the point of diversion of the respective locations that fully ninety per cent of the 1,500 investigated were made only for speculative purposes. Many water locations have been held for years in plain violation of the spirit and letter of the law, without sufficient work being done upon them to show a bona fide intention to divert water for a beneficial use.

ILLEGAL APPROPRIATIONS SHOULD BE VOIDED.

The Conservation Commission believes that such claims should not only be declared null and void, but that the water rights held under them should be restored to the public control, so that they may be located by others and used.

It is true that any individual who wants to use the water now held

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in illegal cold storage under these voidable, but not voided, locations may do so. But, in order to do that, the individual is compelled to bring suit and expensively litigate the matter through the Supreme Court. Nobody will do that until it becomes actually necessary. The result is that much water is being kept in cold storage, being neither used by those who hold it, nor its use permitted by others.

WATER IS PUBLIC PROPERTY.

Water being the property of the public and its use being valuable to the public, the State should see to it that all unused locations should actually be specifically declared null and void and the water restored to public control. A valuable natural resource like water should not be allowed to be kept in cold storage; and no individual should be compelled to go to the annoyance, trouble and expense, in time and money, necessary to the declaration by the State that the State's property is being held in cold storage in contravention of public policy and the law. It is true that the law declares such water locations null and void. But no agency of the State has been given authority to investigate these locations and bring any sort of a proceeding looking to their actual annulment. The bill proposed by the Conservation Commission proposes to supply this deficiency and to give to the Water Commission the authority to initiate such proceedings.

NOT SOUND PUBLIC POLICY TO PERMIT "COLD-STORAGE" OF WATER.

It is claimed, to be sure, that those who have made such locations and, under them, are keeping valuable water rights in cold storage should be permitted to continue to hold them until some other individuals sufficiently desire possession of them to induce them to bring the necessary suits and spend the necessary money to obtain a final annulment of them. The Conservation Commission does not believe that it is sound public policy for the State to permit anybody to break and continue to break the law. Nor does the Commission believe that it is sound public policy to permit anybody to cold-storage a natural resource so essential to the public welfare as water is. And the Commission also believes that it is not sound public policy for the State to compel individuals to spend their time and money to take public property out of cold storage and make it available for the use of the public.

Rather than enter into long and costly law suits for the restoration to the public's use of cold-storaged water rights, many persons and corporations have paid the illegal holders of such rights large sums of money to relinquish or transfer them. Such expenses the public is, of course, made to repay to those who incur them. The Conservation Commission does not believe that the public should be compelled to pay this cost of blackmail for the enjoyment of the use of its own property. The public should be protected from this sort of thing by the empowering of an agent of the State to restore to the public all

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water locations which have not been or are not being developed and put to use as the law plainly requires that they shall be.

APPROPRIATORS SUPPOSED TO KNOW LAW.

It is claimed that this will work hardships upon those who made the locations. The locators are supposed to have known the law when they made their locations and not to have forgotten since then what the provisions of the law are. They, therefore, exercised their location rights with a presumably full knowledge of the law and their obligations under the law, and are attempting to hold the property of the public knowing that they are breaking the law. The Conservation Commission does not believe that it is good public policy to suspend the law because its enforcement may work supposititious hardship upon him who is knowingly or even unknowingly breaking the law.

PUBLIC SHOULD BE PROTECTED.

Finally, the Conservation Commission does not believe that it is good public policy to compel the public to pay any more for the enjoyment of the use of its property than is actually necessary to provide the artificial means to put that property to a beneficial use. The right to use the property of the public for the public's benefit should not, the Conservation Commission believes, be permitted to become, at the cost of the public, the subject of private speculation by illegal or even legal means.

For all these reasons, therefore, the Conservation Commission insists that the State should empower the Water Commission to initiate proceeding for the annulment of illegal appropriations of the waters of the State.

WATER LAWS OF OTHER STATES AND COUNTRIES.

As it was necessary for the Commission to have at hand a digest of the laws of the various nations and the states of the Union in regard especially to forestry and water laws, Mr. Milton T. U'Ren, then in the city of Washington and therefore able to avail himself of the Congressional Library, was employed to collect these data for the Commission. His final report is as follows:

FINAL REPORT OF THE INVESTIGATION OF THE STATUTES, LAWS AND CONSTITUTIONAL PROVISIONS RELATING TO WATER AND WATER POWER.

In presenting this final report of the investigation of existing legislation pertaining to water and water power I shall set forth the scope of the field covered and shall give a brief summary of previous reports rendered.

In the United States the efficient regulation of the use of water must come from the several states. The Federal control is merely incidental. The Federal Government exercises control through its power over navigable streams and as the owner of the public domain. The Federal Government has no laws dealing directly with water and water power. It exercises control indirectly through the departments. Through the War Department it exercises control over navigable streams. It has been the practice to require as a condition of any grant to obstruct navigable streams or to use the water thereof that the grantee conform to certain provisions set forth in the grant. Acts of Congress granting the right to dam navigable streams or to

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divert their waters have many times likewise contained conditions giving the Federal Government the right to control the use of the water or water power resulting therefrom. The Bureau of Forestry of the Agricultural Department controls the construction and operation of water power plants on the Federal domain, but fixes certain conditions to the grants permitting individuals to use the public domain. These practices of the Federal Government have been severely criticised by those claiming a desire to develop the country, but in the absence of state laws on these subjects the actions of the Federal officials have been the only thing standing between the public and the complete gobbling up of all reservoir sites by private speculators. No doubt a plan of coöperation between the Federal Government and the states will be worked out which will permit the development and use of water and water power sites on the Federal domain as rapidly as is required by the public.

In examination of the state laws I find that there are eighteen states which are known as irrigation states. This designation comes from the fact that irrigation is a necessity to farming operations. The laws regarding water in those states have therefore of necessity been more highly developed than the laws of the other states. I have carefully gone over the laws of each of these states indexing them and have filed the same with the Commission under the card index system. In doing this I have presented one thousand six hundred and twenty-five cards.

This card index has been arranged in such form that anyone desiring to ascertain the law, or any particular feature of the water laws, of any particular state can find it by turning to the subject upon the card index.

The complete result of the investigation of the laws of the eighteen irrigation states has been set forth by me in a chart already filed with the Commission. This chart gives the names of the eighteen irrigation states, sets forth the particular phases of the laws in operation in each state and refers specifically to the statutes and constitutional provisions of that state. In presenting the result of my investigation of the laws of the states to the Commission I have done so in the form of five briefs.

Brief No. 1 is "A General Discussion of the Laws of the States Regarding Irrigation and Water Power." Brief No. 2 is "The Law of California Regarding Water and the Use of Water." Brief No. 3 is "The Doctrine of Riparian Rights and its Relation to Modern Conditions." Brief No. 4 is "The Law Regarding Water Power." Brief No. 5 is "The Control and Regulation of Water and the Use of Water."

Brief No. 1 contains a short history of irrigation, and describes the growth of the subject and the legislation enacted in the irrigation states. It sets forth what states have a system of state regulation of appropriation, what states have a method of adjudicating priorities, and what states have a system of administrative control over water rights.

Brief No. 2 deals with the laws of California regarding water and the use of water. It sets forth the Code sections upon the subject and gives a history of the growth of water rights and the growth of the doctrine of appropriation in the state. It cites and discusses the court decisions interpreting the Code sections. It also discusses the adoption of the doctrine of riparian rights by court decisions.

Brief No. 3 deals with the doctrine of riparian rights. It discusses the origin of the doctrine dating from civil law and the common law and sets forth its growth as a common law doctrine through three stages. The introduction of the doctrine of riparian rights is taken up and discussed, together with the successful efforts to limit its scope. Its nature and its effect upon the development of the West is discussed.

Brief No. 4 deals with the laws relating to water power. It shows that this is a new subject and is one of recent growth. The two states most prominent in dealing with the question are Wisconsin and New York. The Wisconsin law has been declared unconstitutional by the Supreme Court. In New York a law is now pending having been proposed by the Water Commission after years of study. This is a new field and California may perhaps have the distinction of leading the way.

Brief No. 5 entitled, "The Control and Regulation of Water and the Use of Water" deals with the question as to State and Federal control. The statutes and court decisions are discussed, and the conclusion reached that the state is the owner of the water and is the proper authority to give most efficient control. The existing laws dealing with the control of water and water power are discussed and recommendations made for their betterment.

The laws of foreign countries I have investigated, and have compiled the laws

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of the following countries: France, Italy, Spain, Egypt, Australia, and Canada. These have been card indexed. The provisions of the Australian laws are perhaps most instructive as they have been drafted and put into force by Elwood Mead, former irrigation investigator for the Federal Government, and the author of the Wyoming water laws.

The principal lesson to be gained from the irrigation countries of Europe is the necessity for a central control. Either the use of water is controlled through a strong central organization of those using it, or by the government. The government being the stronger power has exercised the most successful control.

The result of these investigations has led me to the conclusion that the Oregon water law is probably the best as yet devised for modern conditions. The most immediate and pressing need is for authority to be granted to some Commission for the purpose of determining existing rights subject to confirmation by the Courts. This is the Oregon plan and it worked out admirably.

Respectfully submitted.

(Signed) MILTON T. U'REN.

The card index, the chart and the briefs referred to above, are on file in the office of the Commission and are available for inspection.

PUBLICATION OF OTHER WATER DATA.

Besides the data embraced in this report, a great mass of other data has been gathered, by the U. S. Departments of Agriculture and Interior, under the coöperative agreements with the Water Commission and the Conservation Commission. These data are of great value, but their bulk is so great as to preclude their publication in this report, therefore they have been published by the United States Government and made available for immediate use. Some of these reports have already been published and are distributed, on application, free to all interested persons, by the U. S. Geological Survey, or by this office. The following is the list of those already published and ready for distribution:

295. Gazetteer of Surface Waters of California. Part 1. Sacramento River Basin.
296. Gazetteer of Surface Waters of California. Part 2. San Joaquin River Basin.
297. Gazetteer of Surface Waters of California. Part 3. Great Basin and Pacific Coast Streams.
298. Water Resources of California. Part 1. Stream Measurements in Sacramento River Basin.
299. Water Resources of California. Part 2. Stream Measurements in San Joaquin River Basin.
300. Water Resources of California. Part 3. Stream Measurements in Great Basin and Pacific Coast River Basins.

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FORESTRY.

INSPECTION OF TIMBER AREAS.

During the summer of 1912 the Commission made an inspection of the coast timber areas of the northern part of the State, discussing with the owners of timber and the general public the needs for the protection of timber from fire.

Redwood timber in northern California, showing how the logged section has been fired.

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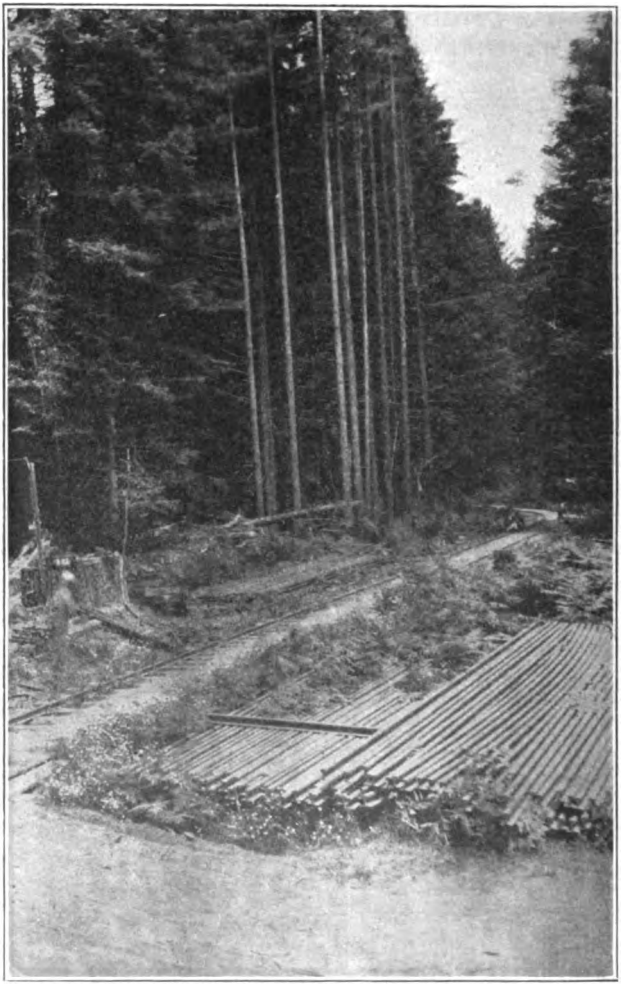

FIG 67.—Young second growth redwood of considerable size, being from 24 to 30 inches in diameter.

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PUBLIC MEETINGS HELD.

The Commission held public meetings in San Francisco and Los Angeles, to which all persons interested in the subject under investigation were invited, in order to obtain opinions from men conversant with the practical and legal aspects of certain tentative measures for the conservation of the waters of the State.

Other public meetings were held by the Commission for the discussion of proposed changes in the laws relative to the protection of the timber and the streams of the State. Those interested in the industries proposed to be affected by any new measures and the public, were invited to discuss and criticize the proposed changes in the laws.

The object of these trips and meetings was to familiarize the Commission, to some extent at least, with the physical conditions pertaining to water power, developed and undeveloped; to observe the cut-over lands and timbered areas in the more heavily timbered portions of the State, and the adaptation of the soil to, and other conditions relative to reforestation.

Many of the persons who appeared before the Commission during these trips and meetings were financially interested in water power, many were lumbermen, and others were citizens generally interested in the proceedings of the Commission. The Commission's purpose in holding these hearings was to acquaint itself with the sentiment existing among all classes of citizens in the sections of the State that would be most affected by changes in the laws relating to water power, irrigation, and forestry. Full stenographic reports of these meetings are contained in the files of the Commission. The Commission believes that the work it has accomplished along these lines is of considerable value.

CESSION OF LANDS TO REDWOOD PARK.

Believing that the area of state-owned forests should be enlarged, and that certain lands owned by the United States should be conveyed to the State for such purposes, the Commission endorsed the act of Congress by which the Federal Government granted to this State additional tracts of land in the four townships adjoining the present area of the California Redwood Park.

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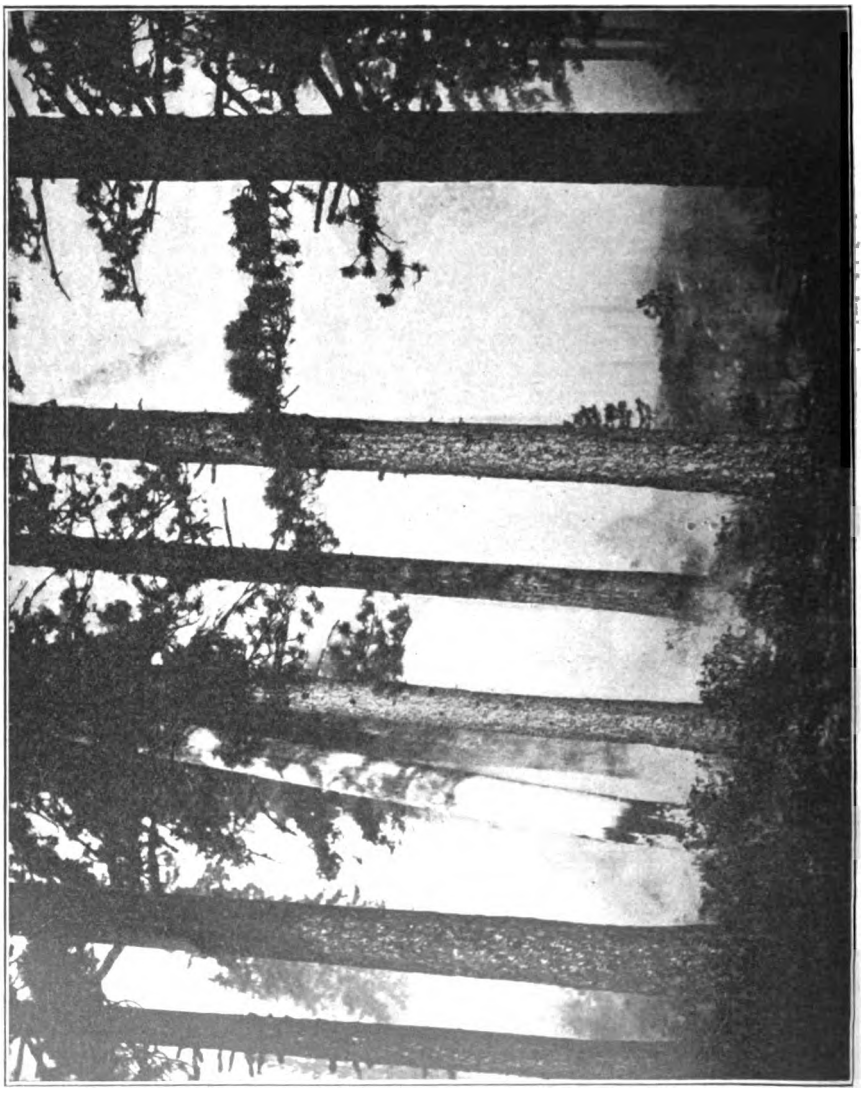
NECESSITY FOR FIRE PROTECTION.

The prevention and suppression of forest fires, it is conceded by everyone, is the greatest problem that conservationists have to deal with. Upon its solution depends the success of all the other measures for forest protection. A forest fire may not only destroy virgin timber,



Fire running through pine timber. This light method of burning is employed by some large timber holders.

but menaces the water supply, and fish and game, and makes difficult the successful application of reforestation methods to the areas burned over. The framing of a measure containing a system for the prevention of fires is the aim of all conservation bodies of the country. Nothing

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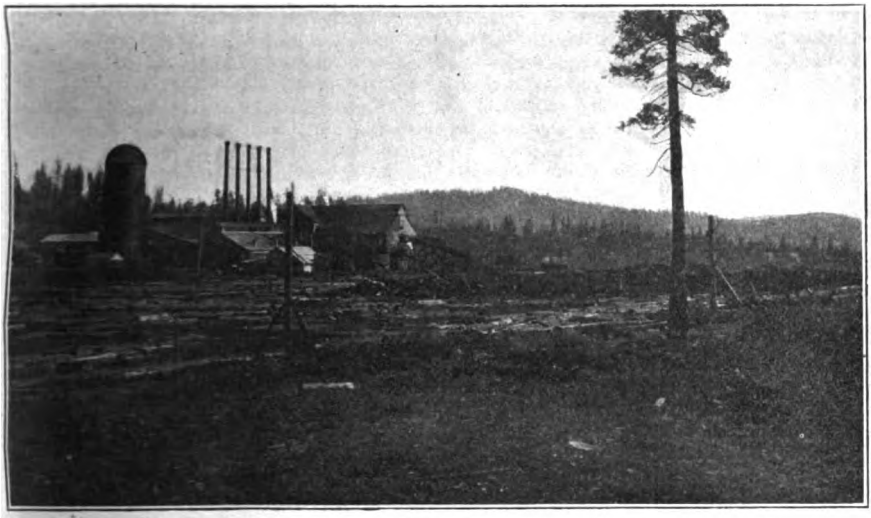
can be accomplished in this direction without adequate appropriations to put into execution such a system. Fires in forests have always followed timber cutting, with the result that many thousand acres of land are now barren wastes covered with blackened stumps, worthless shrubs and chaparral. These worthless growths not only serve as a



The Diamond Match Company's mill at Sterling City, Butte County.

dangerous fire menace, but, in addition, choke out and kill the natural second growth that would develop into merchantable timber under more favorable conditions.

STATE FORESTER'S REPORT ON FOREST FIRES.

The State Forester in his biennial report for 1910, says:

"There are about 30,000 square miles of forested land within the State. Timber on this area is estimated at three hundred billion feet, board measure, with a stumpage value of approximately $700,000,000 and a manufactured value of at least six times as much. Each year the lumber industry puts more than $20,000,000 into circulation. Here surely is an enormous asset which under improper treatment will rapidly disappear, but which properly handled will last for all time."

COÖPERATION WITH LANDOWNERS.

Further on in this report the Forester states:

"Since many lumbermen are indifferent to fire, or consider slash burning and systematic protection impracticable, it is clearly a duty of the State forest officers to coöperate with the private landowners, and inaugurate plans of fire protection on lumber tracts in representative regions. It is also their duty to enforce the state fire laws, and secure a change of sentiment by an educational campaign. For lumbermen have often been regarded by unthinking persons as enemies of the public. Their property is as a rule so situated that it really does make a difference to the public whether it is handled well or ill. And because conditions of markets and transportation have hitherto been such as to almost compel wasteful methods the lumberman has received the name of vandal, and has often found himself unable to obtain a fair hearing. The noisiest conservationists are apt to be those who know the least about the subject, and the profession and practice of forestry has always suffered most not from its opponents but from its hysterical

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friends. Such are always likely to advocate mischievous legislation to regulate the private handling of timber land. Reasonable legislation most progressive lumbermen have no objection to, but laws might easily be passed that would put them entirely out of business, and with sentiment so strongly against them as at present dare not openly protest. In order to enable lumbermen and timber owners to protect themselves from misrepresentation it was proposed to them to form an association under the auspices of this office. With more than half the timber of the State in private ownership, the attitude of the lumbermen toward forestry is without question of great importance. This office has endeavored to introduce forestry principles in the lumber woods by degrees with the view of working around later toward more and more conservative methods, but always to show the lumberman that the changes suggested are practical and in his own as well as the public interest. Our object is not to force the lumberman by legislation or otherwise to adopt better methods against his will, but to suggest only those changes as are reasonable and show him that those are a good investment. In consequence a number of large concerns are now making a practice of burning over in the fall or spring the area cut over the previous summer in order to reduce fire danger and leave the ground in the most favorable condition for reproduction. Thereafter the area is to be protected.

This is only a beginning, but it represents an enormous advance over the methods of previous years, and in itself if generally adopted will prevent cut-over land from falling into the ruinous state which formerly was almost certain to ensue. It has furthermore been accomplished without sacrificing friendly relations between the lumbermen and this office. If lumbermen had been forced to adopt such methods under penalty for refusal little good would have resulted. No doubt the future will show the need of regulating lumbering to some extent by law. There will always remain some shortsighted lumbermen who will be content to log under the old methods even after conditions have changed to such an extent that they are no longer either necessary or profitable. These will wish to skin their land and neglect it after it is once cut over, and in the interest both of the public and of the more progressive lumberman who wishes to adopt conservative methods public opinion will demand that they be legislated against; proper forestry laws, however, are by no means easy to frame; they must be drawn by experts if they are to work well. The lumberman must be consulted, not necessarily because he has an interest in such laws, but because his knowledge of the subject is the most exact obtainable. Yet with public sentiment the way it is the lumberman is practically barred from participation, especially if his opinion on proposed legislation runs counter to that of the ordinary citizen.

A campaign of education is therefore necessary to show the public (what they least expect) that the foremost practical conservationist is the progressive lumberman, and to organize and systematize this campaign was one of the objects of the proposed association. Other objects were to secure more effective protection from forest fires by coöperation to that end; to get the lumber industry as a whole in closer touch with this office; and to provide an opportunity for lumbermen to discuss with each other affairs relating to their business.

A preliminary meeting was held in October, 1909, in San Francisco, to discuss the question of organizing such an association. All parts of the State sent representatives. The need of an association was shown at once by the great variety of opinions expressed. It was decided, however, that an association should be formed with the title California Forest Protective Association, and a committee was appointed to draw up articles. There was so much delay, however, on the details of organization that the forest fire season came on with no general organization accomplished. One practical result of the meeting was the formation of a small coöperative forest fire association by four redwood companies whose holdings adjoin each other. A further attempt to form a general association will be made this winter."

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STATE FORESTRY APPROPRIATIONS.

For the protection to the public of this valuable forest asset, the Legislature, in 1911, appropriated, for the fiscal years from July, 1911, to July, 1913, the following sums:

Salary of State Forester	$6,000 00
Salary of Assistant State Forester	3,200 00
Salary of Deputy State Forester	3,600 00
Printing for State Board of Forestry	2,500 00
Expenses of State Board of Forestry	15,000 00
	$30,300 00

No part of this sum has been, or can well be expended for fire protection. It is necessarily used largely for traveling expenses and the employment of additional assistance. Had the Legislature, at the last session, appropriated money for the protection of the water sheds of navigable streams, the Federal Government, under the provisions of the "Weeks Law" would have been authorized to place at the disposal of the State an amount equal to the amount so appropriated by the State, not in excess of $10,000.

NUMBER OF AND DAMAGE BY FOREST FIRES.

The State Forester, Mr. G. M. Homans, informs this Commission that, during the year 1909, there were 357,269 acres of forest land burned over in this State, "destroying merchantable timber worth fully $100,000, and buildings to the amount of half a million dollars." In 1910, according to the State Forester, "519,463 acres were burned over, and the direct damage amounted to $683,989.20." In 1911, "282,284 acres were burned over. The damage was estimated to be $128,451.50. In 1912, up to November 1, 92,920 acres were burned over."

The State Forester further shows in his report for June, 1912, that there were 738 forest fires in California during the year 1910. This resulted in a loss of over half a million dollars. These fires were caused in various ways, but most of them could have been prevented. The report continues: "263 were of unknown origin, campers were responsible for 122, lightning 119, miscellaneous 76, incendiary 70, brush burning 54, railroads 17, and sawmills 17. In such a state as ours, forest protection alone can maintain the stream flow for irrigation, can prevent destructive forest fires and can provide for all time a timber supply sufficient to perpetuate our wood using industries. The situation is serious and there is only one remedy. That remedy is the introduction of practical forestry on a large scale, and, of course, that is impracticable unless an intelligent economical plan for fire control is operative. When the general public, timber owners, and the State are thoroughly alive to the necessity for fire protection then and only then will the chief stumbling block be removed."

The destruction of timber by fire results in less work for the laborer, less taxes for the county, less shipping for rail and water transportation, and less income to the people of the State generally. It means that

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certain areas of land are rendered valueless for any purposes. It means danger to the streams, springs and other sources of water supply for all purposes.

OWNERSHIP OF FORESTS.

Of the standing timber in this State a very large percentage is now privately-owned. The total acreage of the privately-owned timber and the counties in which such timber is situated are as follows:

Name of county.	Acreage.
Mendocino	475,318
Trinity	233,840
Marin	11,597
Lake	10,320
Butte	89,737
Riverside	4,784
Yuba	19,400
Glenn	16,796
Tulare	33,358
Santa Cruz	19,956
San Luis Obispo	2,040
San Bernardino	10,940
Santa Barbara	160
San Diego	23,460
Kern	8,600
Ventura	803
Fresno	19,983
Tuolumne	131,378
Mariposa	35,073
Madera	23,176
Placer	156,949
Monterey	81,518
Nevada	60,101
Siskiyou	693,180
Tehama	126,358
Modoc	265,317
Lassen	244,434
Del Norte	109,600
Alpine	3,270
Mono	15,320
Amador	17,903
Sierra	134,176
Sonoma	162,474
San Benito	2,960
Plumas	224,717
Shasta	429,512
Calaveras	68,663
El Dorado	96,820
Humboldt	486,950
Total for State	4,555,941

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The timber areas owned in these counties and the manner in which they are held is more definitely shown in the following tabulations:

Groups.	Approximate acreage of individual holders.	Number of holders.	Amount of timber in acres.	Per cent of total.
1	Over 500,000	2	1,536,238	33.70
2	Over 100,000	1	156,696	3.44
3	Over 50,000	6	399,309	8.78
4	Over 20,000	21	671,155	14.77
5	Over 15,000	18	304,757	6.68
6	Over 10,000	19	236,052	5.18
7	Over 5,000	41	279,654	6.12
8	Under 5,000	1,165	971,580	21.33
Totals		1,273	4,555,941	100.00

Further data, embracing the ownership of forest lands in this State and containing the names of the owners of and the amount of such land owned by each such owner, together with the counties in which such holdings are located, are attached hereto and marked Exhibit "A."

MAP OF TIMBER HOLDINGS.

A timber map has also been prepared by this Commission, showing the geographical location and acreage of the holdings set forth in the above referred to tabulation. This map is attached hereto and marked Exhibit "B." The full information relative to the holdings of the Pennsylvania Lumber Company, Michigan Trust Company, and Vance Lumber Company (see Group 4 of table), was not available at the time the timber map was prepared. For that reason their holdings are shown on the map as being among those owning less than 20,000 acres of timber land.

TAXATION OF FORESTS.

This question has been a vexed one for a long time. The owners of forests claim that the annual taxation of standing timber is an ever increasing incentive to the cutting of the timber and the consequent early destruction of the forests. The timber men point to the fact that timber is as much of a crop as grain; but that, unlike grain, which ripens annually and is cut, timber ripens only at intervals of many years and should not be cut before it is ripe, if an economic waste is to be prevented. The timber men also call attention to the fact that growing crops of grain and fruit trees and vines, before they reach the productive age, are, by constitutional provision, exempted from taxation, and that grain, fruit and the products of the vine are taxed only after they are harvested or picked. The timber men, therefore, claim that it is unfair to tax growing crops of trees; and that this natural resource ought not to be taxed until, having been harvested, it takes the form of cut lumber or timber. They assert with not a little plausibility, that such a tax system would result in a longer conservation of the forests.

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On the other hand, though, it is claimed that, because of its annual increase in volume, and because of its constantly increasing annual value, on account of the constantly decreasing supply, a forest should be annually taxed in order that the public may annually receive its proper share of its annual taxation-product. It is also pointed out that, in many counties of this State, the area of privately-owned forests is so great that, were the standing timber not annually taxed, it would be impossible for such counties properly to carry on their county governments or to keep their public schools open.

The owners of forests, however, meet this argument by saying that there would be nothing unfair in annually assessing, at its value as bare land, and annually taxing as bare land the timbered areas of the State, just as agricultural and other lands are assessed and taxed, leaving the timber to be assessed and taxed, as grain crops are, when it is cut.

The Conservation Commission is free to confess that this subject-matter is one to which it has, as yet, been unable to give sufficient attention to enable it to formulate any recommendation to the Legislature.

STATE FORESTER'S DATA ON FOREST TAXATION.

Preliminary data have been gathered by State Forester Homans in coöperation with the Conservation Commission, relative to the taxation of forests, is attached hereto and marked Exhibit "F."

Accompanied by a self-explanatory letter of submittal, it consists of a table setting forth, by counties, the highest and lowest assessments of timber and cut-over lands; the tax rate by counties, and the "estimate of total amount of county tax derived from timber land." It also contains a discussion, by counties, of the assessed valuation and taxation of the various kinds of lands, the tax rates, the amount of timber in each county, etc.

PROPOSED FIRE BILL.

The Commission's proposed forest fire bill, if enacted into law, will, the Commission believes, greatly aid in the prevention and suppression of forest fires. The State should have a well organized fire patrol under the guidance of a practical firewarden, which is the most effective known manner of preventing and suppressing fires. Among other methods advocated is that of volunteer fire associations, but from the information at hand we are of the opinion that this plan works well only in theory. In actual practice it is found that the members hesitate to compel one another to clean up a dangerous fire-menace in the forest, or to take any definite action to prevent fires. The subordinates having the management of these voluntary associations likewise have some hesitancy about ordering the men from whom they draw their salaries to attend to nuisances and other matters that may have been neglected. This is especially true as to the member who subscribes most liberally.

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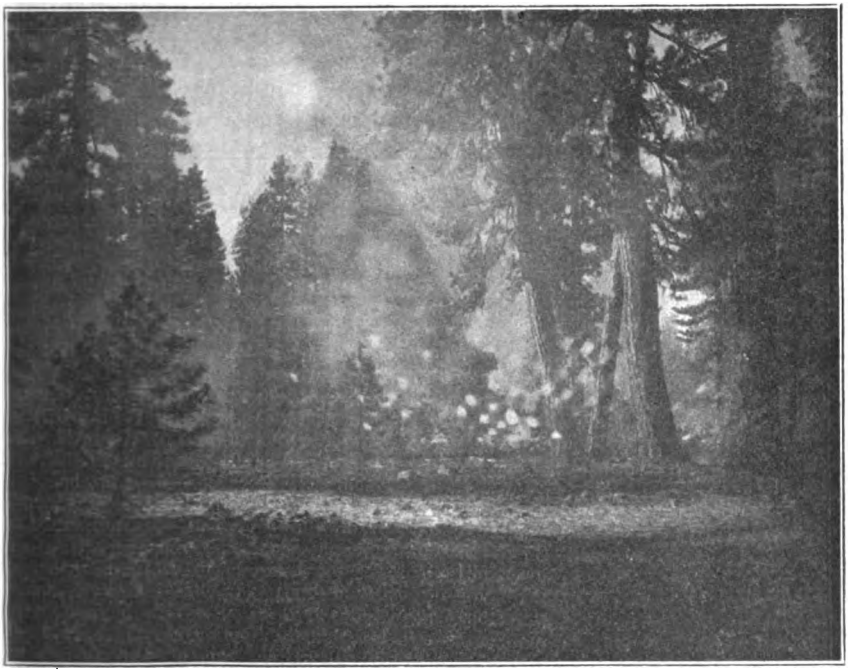
A fire in brush and cut-over lands frequently does as much damage as a fire in standing timber. The fires in the brush in the southern part of the State have threatened the water sheds and diminished the water supply upon which the fruit grower is dependent for the irrigation of his orange groves and other crops in that section. With



Light burning methods used by some of the large timber holders.

the expenditure of a comparatively small sum of money, during the dangerous seasons, in the maintenance of fire patrols, this danger and damage would be greatly lessened, if not eliminated.

States suffering from the results of large and disastrous fires, costing millions of dollars and, in some cases, many lives, are realizing that the prevention of fires is more effective and economical than fighting fires after they are started.

The great difficulty in devising a plan for an adequate and permanent system of forest fire prevention and suppression is in securing an appropriation sufficiently elastic to bear the burden of unusual and unexpected heavy demands upon it for the actual fighting of fires. It is a comparatively simple matter to make an estimate of what it will cost to employ the necessary number of rangers to patrol a forest, but if a number of large and disastrous fires should break out and the State should have to employ extra men to fight them, thereby incurring a large and unforeseen expense, it would tend to cripple the regular patrol force and render the whole system ineffectual. The timber

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owners, who receive the benefits, should be called upon for at least a part of the extra expense incurred in forest fire protection.

It would be impossible for the authorities to ascertain in every instance who is directly responsible for a fire. Therefore, the law makes it the duty of each land owner to extinguish a fire originating on his own land. (See Sec. 2, Chap. 699, Act May 1, 1911; and Sec. 18, Chap. 264, Laws 1905.)

It is a well settled and fundamental principle of the law that if one man performs an act that another is legally bound to perform, he is entitled to compensation for his services, with the proviso that the

Pine timber destroyed by fire.

person bound by law to perform such act, must first receive proper notice. This is a wise and necessary provision in cases where such notice can be given without involving danger and risk in delay. In the case of a fire, however, which is dangerous to life and property, it is obvious that such notice would be ineffectual; for by the time the responsible person received notice the damage would be beyond repair and the fire beyond control.

CONSTITUTIONALITY OF BILL.

This Commission, after examining the laws of other states and the present California fire laws, believes that the provisions of the proposed measure are not only legal but are the most equitable and just for all

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persons affected thereby. Many objections have been made to the proposed bills. Some claim that such provisions will cause undue hardships; while others advance the opinion that certain provisions of the proposed bill are unconstitutional, being a violation of article IV, Section 25, subsections 24 and 33, which are as follows:

"The legislature shall not pass local or special laws in any of the following enumerated cases, that is to say: Subsec. 24. Authorizing the creation, extension, or impairing of liens.

Subsec. 33. In all other cases where a general law can be made applicable."

In this connection the Supreme Court of this State, in *Smith* vs. *McDermott* (93 Cal. 421; 29 Pac. 34), says: "A special law is one relating to a selected class, as well as a particular object."

Chief Justice Morrison in *Ex parte Burke*, 59 Cal. 6, 43 Am. Rep. 231, states what is a general and what a special law.

The court decided in *Abell* vs. *Clark* (84 Cal. 226, 24 Pac. 383, and other cited cases) that "An act applying uniformly upon the whole of any single class of individuals or objects, when the classification is founded upon some natural, intrinsic or constitutional distinction, is a general law."

"General laws are those which operate alike upon all persons to whom they apply." (89 Cal. 522.)

The proposed measure was framed to conform to the provisions of article XIX, section 1 of the Constitution, relative to the "police power" of the State.

In this connection the following citations are applicable:

"Police regulations are not unconstitutional because they may incidentally operate to deprive individuals of their property without compensation, nor because they may create monopoly." (*In re Zhizhuzza*, 147 Cal. 328, 81 Pac. 955.)

"An act giving the Horticultural Commission power to abate a nuisance caused by insect pests in orchards," etc., is authorized by this section. (Art. XIX, Sec. 1.) (*Los Angeles County* vs. *Spencer*, 126 Cal. 670, 77 Am. St. Rep. 217, 59 Pac. 202; *Riverside County* vs. *Butcher*, 133 Cal. 324, 65 Pac. 745.)

In this connection sections 3479 and 3480 of the Civil Code of California are pertinent. As to the power of the State to regulate the abatement of public nuisance, which question is largely involved in the proposed measure, we call attention to the following decisions: *County of Los Angeles* vs. *W. D. Spencer*, 126 Cal. 670, involving the right of the Horticultural Commission to destroy certain diseased trees and to make the owner pay for such destruction.

"The police power deriving its existence from the rule that the safety of the people is the supreme law, justifies legislation upon matters pertaining to the public welfare, the public health and the public morals." (6 Cal. App. 237; *Ex parte Drexel*, 147 Cal. 766, 82 Pac. 429.)

"It is settled law that all property is held subject to police power and that the provision of the constitution declaring that property shall not be taken without due process of law has no application in such cases." *Odd Fellows Cemetery Co.* vs. *San Francisco*, 140 Cal. 230.)

For acts of the legislature conferring powers similar to those contained in the proposed bill, the following citations will suffice:

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Power to abate nuisance and make charge therefor a lien on property. (Section 3028, Pol. Code.)

The rat and squirrel nuisance law confers a similar power. (Sec. 2506*a*, General Laws.)

State Board of Horticultural Examiners authorized to destroy infected trees and charge cost to the land, etc. (Sec. 2322*a*, General Laws.)

OPINION OF SUPREME COURT OF MAINE.

As to whether the Legislature has the right to enact such a law, as is now proposed, in its exercise of the police power conferred upon it by the constitution, we believe that the question cannot be better answered than in the language contained in the opinion of the Supreme Court of the State of Maine. In March, 1908, the Legislature of that state submitted to the Court the question whether or not the Legislature could pass laws restricting, prohibiting, or regulating the cutting or destruction of trees on wild or uncultivated land by the owner thereof and whether such restricting, prohibition or regulating would be regarded as such a taking of private property for public use as would demand compensation for the owner. The opinion of the court is so clear and the principles laid down therein so far reaching in their effect, that it is necessary to print a copy thereof in full, viz.:

"The undersigned justices, in obedience to the requirements of the constitution, severally give the following as their advisory opinion upon the questions of law submitted to the justices of the supreme judicial court by the senate order of March 27, 1907:

"We find that the legislature has by the constitution 'full power to make and establish all reasonable laws and regulations for the defense and benefit of the people of this state, not repugnant to this constitution nor that of the United States': Constitution of Maine, Article IV, Part III, Section 1. It is for the legislature to determine from time to time the occasion and what laws and regulations are necessary or expedient for the defense and benefit of the people; and however inconvenienced, restricted or even damaged particular persons and corporations may be, such general laws and regulations are to be held valid unless there can be pointed out some provision in the state or United States constitution which clearly prohibits them. Those we understand to be universally accepted principles of constitutional law.

"As to the proposed laws and regulations named in the senate order, the only provision of the United States constitution having any possible application to such legislation by a state would seem to be that in XIV amendment. As to that provision, we think it sufficient to quote the language of the United States supreme court in *Barbier* versus *Connolly*, 113 United States 27, where, speaking of the fourteenth amendment, the court said: 'But neither the amendment, broad and comprehensive as it is, nor any other amendment was designed to interfere with the power of a state, sometimes termed its "police power," to prescribe regulations to promote the health, peace, morals, education and good order of its people, and to legislate so as to increase the industries of the state, develop its resources and add to its wealth and prosperity.' It may be added that the proposed laws and regulations would not discriminate between persons or corporations but only between things and situations, with a classification not merely arbitrary but based on real differences in the nature, situation and condition of things.

"We think the only provision in the state constitution that could be reasonably invoked against the proposed laws and regulations are the guaranteed right of 'acquiring, possessing and defending property' and the provision that 'private property shall not be taken for public uses without just compensation.' (Dec. of Rights, Sections 1 and 21.) If, however, the proposed legislation would not

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conflict with the latter provision, it evidently would not with the former; hence, only the latter one need be considered.

"The question of what constitutes a 'taking' of private property in the constitutional sense of the term has been much considered and variously decided. In the earlier cases and in the older states the provision has been construed strictly. In some states, in later cases, it has been construed more widely to include legislation formerly not considered within the provision. Still more recently, however, the tendency seems to go back to the principles enunciated in the earlier cases. In Massachusetts, one of the earliest states to adopt the constitutional provision, and in Maine, adopting the same provision in succession, the courts have uniformly considered that it was to be construed strictly as against the police power of the legislature.

Commonwealth versus *Tewksbury*, 11 Met. 55, decided in 1846, was a case where the legislature prohibited the owners from removing 'any stones, gravel or sand' from their beaches in Chelsea as necessary for protection of Boston harbor. The court held that the statute did not operate to 'take' property within the meaning of the constitution, but was 'a just and legitimate exercise of the power of legislature to regulate and restrain such particular use of property as would be inconsistent with or injurious to the rights of the public.' *Commonwealth* versus *Alger*, 7 Cush. 53, decided in 1851, was a case where the defendant was prohibited by statute from erecting and maintaining a wharf on his own land (flats) beyond certain fixed lines. The court held that the defendant's title to the land (flats) was a fee simple, and that but for statute he would have had full right to erect and maintain wharfs upon any part where they would not obstruct navigation. It was not claimed that the proposed wharf would obstruct navigation but rather admitted that it would not. The court further held, however, that the statute was within the legislative power and not forbidden by any clause in the constitution. The question was considered at length in an opinion by Chief Justice Shaw, and the principle stated as follows:

" 'We think it a settled principle, growing out of the nature of well ordered civil society, that every holder of property, however absolute and unqualified may be his title, holds it under the implied liability that his use of it shall be so regulated that it shall not be injurious to the equal enjoyment of others having an equal right to the enjoyment of their property, nor injurious to the rights of the community. All property in this commonwealth, as well that in the interior as that bordering on tide waters, is derived directly or indirectly from the government and held subject to those general regulations which are necessary for the common good and general welfare. Rights of property, like all other social and conventional rights, are subject to such reasonable limitations in their enjoyment as shall prevent them from being injurious, and to such reasonable restraint and regulations established by law as the legislature, under the governing and controlling power vested in them by the constitution, may think necessary and expedient. This is very different from right of eminent domain,' " etc.

"In the case *Wadleigh* versus *Gilman*, 12 Maine, 403, decided in 1835, only fifteen years after the adoption of our constitution, there was upon the plaintiff's land a wooden building. A city ordinance was passed by legislative authority prohibiting the erection of wooden buildings within certain limits, which included the plaintiff's building. After the passage of the ordinance the plaintiff moved his building to another place within the same inhabited limits. The defendant, as city marshal, acting under the ordinance, entered upon the plaintiff's land, took the building down. The court held the ordinance valid and the defendant protected, and declared as follows (p. 405): 'Police regulations may forbid such a use and such modifications of private property as would prove injurious to the citizens generally. This is one of the benefits which men derive from associating in communities. It may sometimes occasion inconvenience to an individual, but he has compensation in participating in the general advantage. Laws of this character are unquestionably within the scope of the legislative power without impairing any constitutional provision. It does not appropriate private property to public uses, but merely regulates its enjoyment.' "

"In *Cushman* versus *Smith*, 34 Maine, 247, decided fifteen years later, in an elaborate opinion by Chief Justice Shepley, the court said of the constitutional provision in question (page 258) 'The design appears to have been simply to declare that private property shall not be changed to public property, nor transferred from the owners to others for public use without just compensation.' In *Jordan* versus *Woodward*, 40 Maine. 317, it was said by the court at page 324:

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'Strictly speaking, private property can only be said to have been taken for public uses when it has been so appropriated that the public have certain and well defined rights to that use secured, as the right to use the public highway, the turnpike, the ferry, the railroad and the like.' The same doctrine was recognized in *Preston* versus *Drew*, 33 Maine, 558; *State* versus *Gurney*, 37 Maine, 156; *Boston & Maine Railroad Company* versus *County Commissioners*, 79 Maine, 386; and as late as 1905, in *State* versus *Robb*, 100 Maine, 180.

"There are two reasons of great weight for applying this strict construction of the constitutional provision to property in land: First, such property is not the result of productive labor, but is derived solely from the state itself, the original owner; second, the amount of land being incapable of increase, if the owners of large tracts can waste them at will without state restriction, the state and its people may be helplessly impoverished and one great purpose of government defeated.

"Regarding the question submitted, in the light of the doctrine above stated (being that of Maine and Massachusetts at least) we do not think the proposed legislation would operate to 'take' private property within the inhibition of the constitution. While it might restrict the owner of wild and uncultivated lands in his use of them, might delay his taking some of the product, might delay his anticipated profits, and even thereby might cause him some loss of profit, it would nevertheless leave him his lands, their product and increase, untouched, and without diminution of title, estate or quantity. He would still have large measure of control and large opportunity to realize values. He might suffer delay but not deprivation. While the use might be restricted it would not be appropriated or 'taken.'"

"The foregoing considerations lead us to the opinion at present that the proposed legislation for the purposes and with the limitations named in the senate order, would be within the legislative power and would not operate as a taking of private property for which compensation must be made."

Respectfully submitted.

LUCILIUS A. EMERY.
WM. P. WHITEHOUSE.
S. C. STOUT.
HENRY C. PEABODY.
ALBERT M. SPEAR.
LESLIE C. CORNISH.

March 10, 1908.

This idea is also very well expressed in the case of *Hudson Water Co.* vs. *McCarter*, contained in 209 U. S. 349:

"The State as quasi-sovereign and representative of the interest of the public, has a standing in court to protect the atmosphere, the water, and the forests, within its territory, irrespective of the assent or dissent of the private owners immediately concerned." (*Kansas* vs. *Colorado*, 185 U. S. 125); (*Georgia* vs. *Tennessee Copper Co.*, 206 U. S. 230.)

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REFORESTATION.

The subject of reforestation is one of the most important that confronts this country. Our timber supply will, at present rate of forest destruction, be exhausted in less than fifty years. Efforts to encourage tree planting and forestry have been made at different intervals and by different methods for the last twenty-five years. These efforts have not been attended with success, for the reason that the work has not been put in the control of the proper agency. Inducements have been offered to individuals to practice tree planting; but when the inducement is withdrawn, tree planting ceases.

Young eucalyptus trees that have been planted on cutover redwood land, as a protection to young second growth redwood.

Reforestation is the duty of the Federal and State governments, especially during its experimental period, because it is particularly for the benefit of future as well as present generations, and consequently does not, under present conditions, encourage the investment of private capital. Enterprises offering returns on the investment during the life time of the investor are naturally more attractive than those which are experimental or for realization in the far future. The Federal and State governments must, therefore, by their example, encourage the owner of large areas of cut-over land to reforest those lands.

Instead of being a source of extra taxation, forestry, when properly handled, will become the medium of greater income to the State. By proper reforestation, the forests will become self-sustaining and a source of profit to the State, as they have been in the past to the private owner. For every dollar the timber owner makes out of timber,

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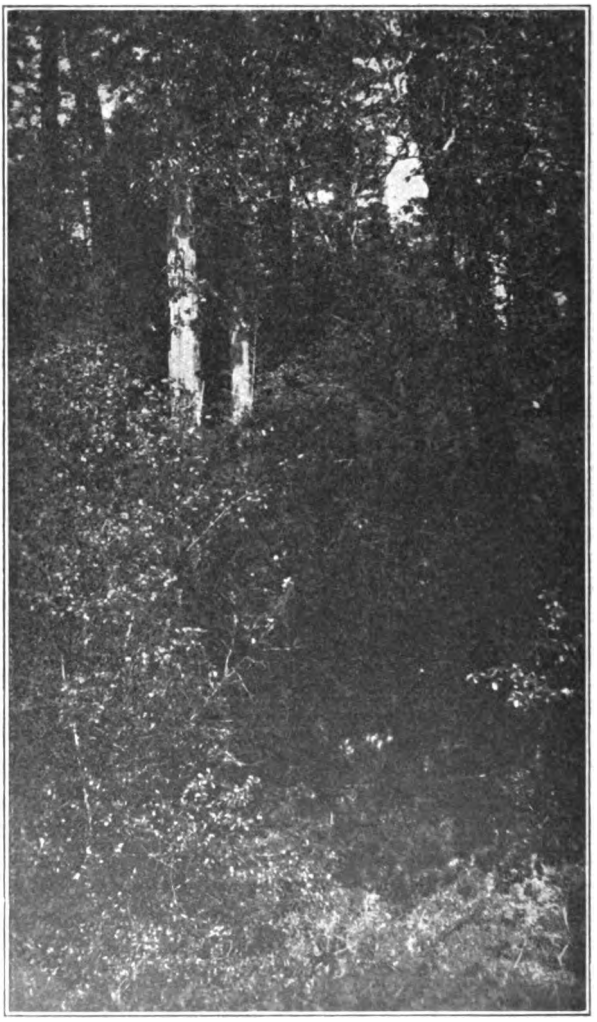
the community and state generally make two. This is because of the creation of business and the circulation of money through the employment of labor in the woods, mills and other places necessary to conduct a lumber business. Maine, New York, Wisconsin, Minnesota and a great many Eastern States have purchased lands for reforestation purposes.



Good, natural redwood second growth on the Ten-Mile River, Mendocino County.

They have paid as high as ten dollars an acre for lands, and have purchased many thousand acres.

The California Redwood Park, comprising 3,800 acres is the only state-owned forest land in California. No provision has been made for obtaining other land for State forests. In that respect we have

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failed to keep pace with certain Eastern States, and also with a number of the Western States.

We are not yet awake to the urgent need of growing more timber. Many are of the opinion that the need does not exist; but this class of people consists chiefly of those who are not acquainted with conservation problems. A few years ago, Wisconsin, Minnesota, Michigan and other states, thinking there was no danger of their timber supply failing them, made no provision for its preservation or for future forests. The legislatures of these states, and the Southern States as well, are now making laws for the preservation and protection of all their natural resources.

When New York had the forestry problems brought to its attention, lands suitable for reforestation purposes could have been purchased for one dollar and a half per acre. After realizing the need for protecting the forests from destruction and the waterways and streams from pollution and waste and even destruction, the Commission appointed to handle the matter was able to get some land for $3.45 per acre, but had to pay far more than that for other lands.

At present lands for reforestation purposes are at their minimum value in California. It would be to the best interests of the State to purchase cut-over lands at once, before values increase and the timber supply is still further diminished.

RECOMMENDATIONS OF NEW YORK GOVERNORS.

It was recommended to the legislature of New York by Governor Flower, in his message of 1893 in connection with a reorganization of the Forest Commission, (1) "That forest tracts owned by individuals or private associations and used mainly for the purpose of reforestation should be secured as a part of the forest reserve and guarded against denudation by a contract with the State providing for exemption from taxation in consideration of forest protection and restrictions on the removal of timber, and (2) that revenue should be secured to the State by granting permission to fell trees above a certain diameter on State lands and to remove the timber." Legislation embodying these recommendations was enacted in 1893 and the results were stated by Governor Flower in his next annual message, from which the following extracts are quoted:

"The new Forest Commission is now able to report that 225,000 acres of Adirondack land has been offered to the State upon the terms of the proposed contract and the standing spruce timber exceeding twelve inches in diameter has been sold on 17,468 acres of State lands from which it is expected that the first year's cutting will yield to the State a revenue of $52,400. * * * *

"It thus appears that the state forest preserve has been increased by probably a million dollars' worth of lands without any direct appropriation of public money and that the first year of intelligent administration under the new law has insured to the State an annual revenue largely in excess of the entire cost of maintaining the Forestry Bureau. If from so small a portion of the Forest Preserve so considerable a revenue is received without injury to the forests we can reasonably look forward to the time when the Forest Preserve will not only be the great conservator of our water courses and the restorer of health, but will contribute a large part of the money required for the support of the state government."

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Governor Morton of New York in his annual message of 1896 pointed out that "unless these lands are acquired within a reasonable time they can only be obtained at higher cost many years hence."

Governor Black of New York in his annual message of 1897, speaking of the loss to the state of timber through fires, floods and cutting, said: "Some time this deplorable condition must be rectified. Every year the loss to the State becomes greater, in all cases difficult and in some cases impossible of recovery. The land is steadily and rapidly increasing in value." * * * "A subject of such magnitude should not be postponed nor conducted with the halting method which is too apt to distinguish public enterprises in which large appropriations afford convenient resting places in which office holders may grow old." * * * "Every consideration of health, pleasure, economy and safety urge the speedy consideration of this subject."

NEW YORK APPROPRIATES MILLIONS.

Thereupon the legislature appropriated the sum of $1,000,000 for the acquisition of forest lands and created "The Forest Preserve Board" with authority to purchase tracts within the Adirondack Park. With this appropriation the Board acquired over 250,000 acres at an average cost of $3.74 per acre. In 1898 another appropriation was made of $500,000 and in the years 1899 and 1900, under the administration of Governor Roosevelt, $600,000 was appropriated for these purposes. In 1904 there was an appropriation of $250,000. In 1906, $400,000 more was appropriated and this was followed by an appropriation in 1907 of $500,000.

While the greater portion of the money appropriated, as above set forth, was for the purpose of acquiring title to definite tracts of land to be included in the "Adirondack Park" and in the "Catskill Park," the general purpose of acquiring cut-over lands for reforestation purposes was carried out along lines similar to those urged in this report. In that respect the quotations from the various reports and messages to the New York legislature are pertinent. What has been found to be advisable in New York and other Eastern States will be found advisable here. California has an advantage over the Eastern States, in that we can take warning from their experience and adopt precautionary measures before it is too late.

FORESTRY CONDITIONS IN OTHER STATES.

The table appended hereto sets forth the forestry conditions in certain other states—seventeen in number. The states selected, it will be noticed, include those Pacific Slope States in which there are any considerable bodies of timber, together with exemplar states in the extreme East, where, it is commonly supposed, the forests have practically disappeared, as well as examples from the Middle West and the South.

The table gives, for each state, the annual appropriations for forestry

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in 1911, and the amounts actually expended for fire protection; designates by whom the patrol system is maintained; sets forth the method by which money for fire protection purposes is obtained from the owners of forest lands; shows who pays the cost of fighting fires; gives the approximate acreage of forest lands in private ownership, the acreage of state timber lands, and the acreage of forest lands in National Forests.

For this table the Commission is indebted to Mr. T. E. Loynahan.

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APPROPRIATIONS AND EXPENDITURES FOR FORESTRY PURPOSES.

State.	Annual appropriation.	Expended for fire protection.	Patrol systems maintained by—	Method of obtaining money from owners.	Cost of fighting fires paid by—	Acreage of private lands.	Acreage of state timber lands.	Acreage of national reserves.
California	$7,150 00		State and individuals and federal government and associations.	Individuals or association assessments.	Owners	8,500,000	2,000	11,000,000 annually forested; total acreage, 27,667,355.
Oregon	$30,000 00	$13,788 20 Week's law, $3,305.	State and associations and federal government and individuals.	Acreage assessments.	Owners and state.	15,000,000	None	16,000,000
Washington	$38,000 00	$20,151 14	State and associations, federal government and individuals.		State ½; county ½; owners.	5,500,000	1,500,000	11,684,360
Idaho	$15,000 00	Not given	State and associations, federal government and individuals.	Assessments	State and owners.		400,000	19,560,625
Utah	None				County	Slight		7,667,585
Minnesota	$75,000 00	State, $25,675.77; Week's law, $10,000.	State or railroads and federal government.		State		43,297 in 1909	1,204,750
Wisconsin	$35,000 and sale of lands; $60,000 for purchase lands.	Any part of appropriation; Week's law, $4,437 25.	State and federal government.		Towns	10,000 (about)	400,000	
Michigan	$10,000 00	$10,000 00	State		State and municipalities.	39,000 in 1909	39,000 in 1909	163,771

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New York	$224,544 84	$75,000 00	State in fire towns and individuals.	Individual effort.	State ½; town ½; owners.	7,222,000 in 97 fire towns; includes state and private ownership.		
Pennsylvania	$321,250 00	$35,000 on private land; $5,000 for rangers; $35,000 for foresters; $35,000 for labor.	State		State	6,500,000	961,444	
Vermont	$11,000 00	$1,300 00 Week's law, $1,218.	State and owners and federal government.	Voluntary acreage assessment.	Town over 5% of grand list by state.	Total area forest and waste lands, 3,719,000; 800 acres forest land.		
Connecticut	$15,000 00	$1,500.00 for fire fight-ing. Week's law, $6.	State and federal government.		Town ½; county ¼; state ¼.	1,500,000		
New Hampshire	$18,000 00	$12,000 00 Week's law, $6,219.50.	State and association and federal government.	Association assessments on acreage, $10,000.	Town ½; state ½.	4,000,000 acres timber land in state.		
Massachusetts	$49,000 00	$25,000 00 Week's law, $2,500.	State and federal government.		Township	2,400,000		
Maine	$65,000 from tax on wild lands.		State		State and towns.	9,000,000 acres wild land.		
North Carolina	$3,000 00				Owners.			
South Carolina						5,532,000		

N. B.—The above expenditures made under the Week's law were collected for the year 1911. All other figures given are for the year 1912.

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STATE EXPENDITURES FOR FIRE PROTECTION.

From this table it appears that, of California's appropriation, of $7,150, none is spent for fire protection; while Oregon spent, in 1911, $13,788.20, and Washington, $20,151.54. Michigan spent $10,000; New York, $75,000; Pennsylvania, $120,000; Massachusetts, $25,000.

For forestry purposes, New York appropriated $224,544.34; Pennsylvania, $321,250; Massachusetts, $49,000; Wisconsin $35,000, plus the amount derived from the sale of state lands; Maine, $34,000, derived from tax on wild lands; Washington, $38,000; Oregon, $30,000; Connecticut, $20,000; Idaho, $15,000; Vermont, $11,000; Michigan, $10,000; California, $7,150; North Carolina, $3,000.

RESULTS OF FIRE PATROL.

It is true that the damage done by forest fires in California has decreased very rapidly during the past three years. The damage done in 1910, 1911, and 1912, to timber, reproduction and forage in the National Forests, as estimated by the U. S. Forest Service, was, respectively, $332,586.20; $51,000.83; $8,138.81. And the damage to timber alone for these same years was $189,843.00; $7,673.00; $2,217.72. Is there, can there be, any stronger argument in favor of a comprehensive and effective forest fire preventative policy on the part of the State? For, be it remembered, the National Forests are carefully protected, at great expense, by the U. S. Forest Service. And a fire-protective service which reduced, in three years, the total forest fire loss from $332,586.20 to $8,138.81, and the loss in timber alone from $189,843 to $2,217.72 would seem to be well worth while.

FORESTS IN GERMANY.

The German Empire has a total area of 208,800 square miles of land of which area 54,687.5 square miles are timbered. There is much interesting information contained in Circular 140 of the U. S. Forest Service, Department of Agriculture, regarding forest conditions in Germany, portions of which are as follows:

"There is a little over ⅔ acre of forest for each citizen and, though 53 cubic feet of wood to the acre are provided in a year, wood imports have increasingly exceeded wood exports for over forty years, and 300,000,000 cubic feet, valued at $80,000,000 or over one sixth of the home consumption are now imported each year. * * * *

"Like other advanced European countries, Germany felt the pinch of wood shortage one hundred and fifty years ago and though this shortage was relieved by the use of coal, as a fuel, the warning was heeded and systematic State forestry was begun. After all the scare was not a false one, for even today, Germany is not independent as regards wood, since she has to import one sixth of all she uses. * * * *

"The method of management of German forests is regulated so that no more wood is cut than the forest produces. Under this management the growth of the forest and, consequently the amount cut has risen sharply. In 1830 the yield was 20 cubic feet per acre. In 1865, 24 cubic feet; in 1890, 52 cubic feet; and in 1904, 65 cubic feet. In other words Prussian forest management has multiplied the rate of production threefold in seventy-five years. And the quality of the product has improved with the quantity. Between 1830 and 1904 the percentage of saw timber rose from 19 to 54 per cent. Germany received as high as 60 per cent per acre net revenue from her forests. They have ceased to be an expense and are now self-sustaining and a source of considerable profit."

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It is a striking fact, in this connection, that in the United States, at the present time, we are annually using about three times as much timber as our forests annually grow. This is in spite of the fact that for several years the market for lumber has been low and as a result logging operations have been curtailed instead of increased.

Logging operations in the redwoods.

UNUSED LANDS ECONOMIC WASTE.

Every acre of land which is not put to some useful purpose constitutes an economic waste. With few exceptions, all of the states have adopted a system for preserving and increasing their timber supply.

There are 1,544,868 acres of cut-over land in this State usually assessed as grazing land, but they yield little or no revenue for the

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owner. It is believed that, under proper laws encouraging reforestation, there will be thousands of acres of cut-over land donated to the State for reforestation purposes.

The larger the area owned by the State, the cheaper it will be to handle it. The cost per acre for reforestation will be materially lower if the State maintains its own nurseries. In addition to the lower cost, the quality of the trees will be of a higher grade, as care can be taken that diseased trees are not used.

Some of the states have passed laws reducing or abolishing taxes on cut-over lands, with the proviso that the owner of such lands reforest them. The average individual does not possess enough practical knowledge of forestry to enable him intelligently to select and set out trees, so that his attempts are likely to result in a poor and diseased growth.

Logged over redwood land in Mendocino County, showing abundant, natural second growth, which if properly handled would make a fine forest.

Massachusetts has a law, passed in 1908, providing for reforestation. In a report of Mr. R. S. Langdell, Assistant Forester of Massachusetts, for 1910, entitled "Reforestation in Massachusetts," it is stated,

"Under an act to provide for the purchase of forest land and for reforestation passed by the legislature of 1908, provision is made that private owners may turn tracts of land suitable for reforestation purposes over to the State, to be planted and handled under practical forestry management, and such owners reserving the right to redeem the land at any time within ten years, for the actual amount expended.

"During the year 1909 about 1000 acres were deeded to the State and placed under the supervision of expert foresters from the State Forester's Office, the work being done by local gangs, picked up in the various towns where the lots were situated. The cost of planting, including price of trees and labor of setting, ranged from $5.00 to $10.00 per acre, according to land and labor conditions. A large proportion of the trees used in the work were purchased from outside nurserymen; but in the future, by raising the stock in State nurseries, the above cost of planting should be reduced."

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As an example of individual reforestation, attention is directed to the United States Timber Culture Act, repealed some years ago. This act provided that when a claimant to land applied for in conformity with the provisions thereof could show that he had planted trees on each legal subdivision of the tract claimed, he could "prove up" and get a patent. No governmental supervision was had nor was there any direction or condition as to what class of trees should be planted nor what was to be done with them after the planting. In consequence of this policy many of the Western prairies are dotted with the skeletons of stunted aspens, cottonwood, greasewood and other like varieties of so-called "timber."

In an effort to promote tree planting in California, the Legislature some years ago passed a law (subsection 36, sec. 4041, Pol. Code) providing for the payment by counties to individuals of a sum not to exceed one dollar for each ornamental or shade tree planted along roads. With reference to this act, letters were written to all county auditors of the State asking what had been accomplished under the provisions thereof.

Out of a number of replies received only one—that from the Auditor of Colusa County—stated that there had been any work done under the act and that the last money paid therefor was on August 3, 1910.

Mr. S. J. Flintham, the forester of Los Angeles County, states that no money has been spent under the provisions of said act, but that the county has taken advantage of the act creating the county board of forestry and has thus accomplished the same end in a more effective manner. He goes on to say:

"The bounty act, it appears to us, would be likely to result in poorly advised planting and lack of uniformity, at very considerable expenditure of county funds—while under our act all roadside planting is under one authority, and opportunity is given to regulate to secure uniformity, proper selection of species and best results. Furthermore, funds are expended not as a bounty to third parties, but for financing planting operations conducted under the directions of the Board itself. With an appropriation of $25,000 this past year, 1911-12 roadside planting has been completed on stretches aggregating 35 miles of the most important roads of the county. It is expected that a further, and we hope, a larger appropriation, will be made available to extend this work during the coming season."

AGRICULTURAL LAND IN NATIONAL FORESTS.

"Conservation of natural resources" is sometimes briefly defined as "the maximum use of them with only a minimum of waste." This Commission has endeavored to study all of California's natural resources with this definition in mind. It has studied, as well as it could, not only the natural resources belonging to the public, but also privately-owned natural resources, including lands in the National Forest within the boundaries of the State.

The National Forests contain scattered tracts of lands suitable for agricultural purposes. When these lands are "reserved" or "withdrawn" from the use to which they are best fitted, viz., agriculture, an economic waste results. And this Commission, in common with all other citizens, would like to see such lands restored to entry. Such restora-

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tions would be of benefit to the State, to the counties in which they are situated, and to the individuals who acquire possession of them.

But it must not be assumed that all unforested, or even all unforested and rich lands in the National Forests, are capable of producing sufficient agricultural products to put them in the class of "agricultural lands." For conditions of climate, elevation, topography and rainfall or other water supply may be such as to preclude the agricultural use of lands which, under other such conditions, would be very productive.

It is the policy of the U. S. Forest Service to restore to public entry, as fast as may be, all really agricultural lands which may be so restored without injury to the Reserves themselves. The following quotation from the "Rules Governing the General Classification of National Forest Lands and the Segregation of Areas Chiefly Valuable for Agriculture, and Instructions Thereunder," is self-explanatory of this policy of the Forest Service: "A complete and final classification of all lands within National Forests as to their comparative values for forest and agricultural use, and the segregation and listing, under the act of June 11, 1906, of all areas chiefly valuable for agriculture, is an end to be sought for the following reasons: 1. To facilitate the carrying out of the established policy of the Forest Service to open up for settlement and development all land within the National Forests which is chiefly valuable for agriculture. Under this policy the term 'agricultural land' as applied to land within the boundaries of a National Forest is defined as meaning land whose conditions of climate, typography, and soil-productivity positively adapt it to permanent cultivation and the production annually of farm crops in quantities sufficient to justify a reasonable man in undertaking its development."

With this policy of the Forest Service, the Conservation Commission believes, no reasonable man ought to disagree. The National Forests are of the utmost importance to this State. They preserve, on the watersheds of the headwaters of many of our streams, forest cover which serves to regulate the flow in these streams; they conserve great areas of forest lands, which, were it not for the existence of the National Forests, would fall into private ownership and be, first, monopolized and then finally destroyed. Nothing, therefore, should be contemplated or done that will interfere with the integrity and permanence of the National Forests. And under the present policy of the United States Forest Service the segregation and opening to entry, settlement and development of agricultural lands will, no doubt, go on with a sufficient celerity to satisfy the reasonable desires of all men.

WITHDRAWAL OF AGRICULTURAL LAND BURDEN TO COUNTIES.

The Federal statutes now provide that 25 per cent of the moneys realized from the sale of timber in National Forests shall be paid into the treasuries of the counties in which the sold timber is located. This Commission believes that this percentage is not sufficient to reimburse anywhere nearly the counties for the withdrawal from county taxation

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of the National Forests. The Commission, therefore, strongly recommends that the State of California, by appropriate legislative action, and through its Senators and Representatives in Congress, advocate that 50 per cent instead of 25 per cent, of the moneys received by the United States Forest Service from the sale of timber in the National Forests shall be paid into the treasuries of the counties in which such timber is located.

Ten per cent of gross receipts has been added to the regular 25 per cent and is being used in coöperation with the State and County governments in the construction of roads and trails on the National Forests.

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SCHOOL LANDS INVESTIGATION AND DATA.

The Conservation Commission has also collected data relative to school lands. Co-operating with the State Surveyor General, examination of the records in the State Land Office was made to determine what lands, if any, were still owned by the State. The Commission also employed the services of a corps of men, in Washington, D. C., familiar with this class of work to gather data of a similar character at the U. S. General Land Office.

SCHOOL LAND.

With a view to determining the extent, location, and area of school lands, this Commission addressed a communication to Hon. W. S. Kingsbury, the State Surveyor General, and propounded the following questions:

"Will you kindly furnish this office with the following information:
Total acreage school land still owned by State?
Total acreage school land sold?
Total acreage school land granted to State?
Approximate acreage school land within unsurveyed townships not yet listed to State?
Total acreage still owned by State under swamp land grant?
Total acreage owned by State under other grants? Give each grant separately.
Has any examination been made to ascertain the character and value of the state lands?
If so, please state the extent of such work and where such information may be obtained.
Is school land first appraised before it is sold?
Upon what terms is it sold?
At what price and under what conditions are the other state lands sold?
Are these lands first appraised?
Can the State lawfully refuse to sell any of its lands, or must it sell when proper application is made?
As much of this information as you can supply before September 15th, the date of our next meeting, will be greatly appreciated, since the Commission would like to consider these questions at that time."

Mr. Kingsbury, in reply to our inquiry stated that:

"The acreage of school land granted to the State, acreage sold, and acreage still owned by the State, has never been tabulated. * * * *
The State has sold all swamp land with the possible exception of a very few isolated tracts.
The only lands granted to the State which remain unsold are the school lands.
No examination has been made to ascertain the character and value of the state lands.
No lands are appraised before they are sold.
The school lands must be sold, under the present law, at $2.50 per acre when proper application is made. * * * *
If there is any timber on the land, it goes with the land without additional charge. There is, at present, no known timber land."

Mr. Kingsbury in his communication also stated that until certain matters are adjusted "it will be impossible to make even the roughest kind of an estimate of the amount of land owned by the State."

Owing to the condition of the records of our State Land Office, and the methods which, prevailing long before Mr. Kingsbury became

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Surveyor General, undoubtedly caused this confusion and uncertainty, the Commission determined to ascertain, if possible, what lands, if any, the State still owned. And, in order that, if valuable land was discovered, it would not be practically given away for the nominal sum of $2.50 per acre, the Commission recommended to the last extra session of the Legislature the withdrawal from sale of state lands until September, 1913; and the recommendation of the Commission became a law.

As a result of the investigations made under the direction of this Commission, greatly aided by Mr. Kingsbury, of the official records of the Federal Government, the Commission has been able to approximate the total amounts of land still owned by or due the State, and has prepared a map showing the geographical locations, and as near as possible, the area of such school lands. The map referred to is numbered Exhibit "C" and is attached to this report. A tabulation giving the status of each section 16 and 36, in which the State has an apparent claim to all or a portion thereof, is shown upon the following pages. The only purpose of this map and the tabulation is to give a general idea of the geographical location and area of the state lands.

The tabulation showing the location and area of each section in which the State may have an interest, and also whether or not the land is within or outside a National Forest Reserve, is appended hereto and marked Exhibit "D."

We do not desire to assert that this tabulation or description of the school lands appended hereto is entirely free from error, because, in a few instances, since the preparation of the table, we have found certain discrepancies. This is due, however, to the condition of the old records in the office of the State Surveyor General. But, as stated before, the purpose of this investigation and inventory was not to make an absolutely exact check, but merely to determine approximately the area, if any, of state lands still in the State's possession. And, in view of the tabulation made, we are confident that the State still owns approximately one million acres of school lands.

LETTER OF CERTIFICATION.

The following letter certifying to the apparent and probable correctness of the data gathered at Washington in regard to the California school lands is self-explanatory:

(COPY)

UNITED STATES DEPARTMENT OF THE INTERIOR.
GENERAL LAND OFFICE.
WASHINGTON, D. C., April 22, 1912.

State Conservation Commission,
State of California,
Mills Building, San Francisco, Cal.

SIRS: In furtherance of the adjustment of the California School grant, representatives of the State, acting with officials of this office, have examined the records of the office pertaining to said grant, and have prepared a tabulation, in triplicate, therefrom, showing the present status of the grant, pending unapproved selections being excepted. The records were carefully examined and checked, and the data obtained and tabulated is believed to show correctly the status of the grant. It

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must not be considered, however, that such statements, while deemed to be accurate, are to taken as conclusive and as forbidding subsequent ascertainment and correction of errors.

Very respectfully,

(Signed) S. V. PROUDFIT,
Assistant Commissioner.

CONDITION OF SCHOOL LANDS.

The compilation showing the status of the California school land grant as secured from the records of the State and Federal departments shows:

	Acres.
Sold by State	2,833,205.83
Selections made prior to March 1, 1877	587,778.22
Selections made subsequent to March 1, 1877	576,867.06
Excess selections subsequent to March 1, 1877	3,228.94
Land in place claimed by the United States, act March 1, 1877	14,590.43
Reconveyed to United States	12,000.00
Total disposals by the State of California	4,027,669.98
Area due the State of California under school land grant (surveyed and estimated)	5,252,143.19
Area due (353 townships unsurveyed and unestimated), approximately	447,360.00
Total area due the State of California	5,699,503.19
Area due the State of California	5,699,503.19
Total area disposed of by State	4,027,669.98
Balance due the State	1,661,833.21
Pending unapproved selections	486,768.55
Total area undisposed of	1,175,064.66
Excess selections, prior to March 1, 1877	17,945.20
Payment claimed by the United States for excess selections prior to and under the provisions of the act of March 1, 1877, at the rate of one dollar and twenty-five cents per acre	$22,431 50

DOUBLE SALE OF LANDS BY STATE.

The lack of system formerly existing in the State Surveyor General's office has, in not a few instances, resulted in the State selling, to citizens entitled to purchase, lands which, through prior transactions, the State had already disposed of to other applicants. This may result in much litigation as well as in hardship to bona fide purchasers, who, in some instances, may even be deprived of their homes and the improvements made upon these lands which they have made in good faith upon the assumption that the State was not selling then an imperfect and defective title. Under the present law all that these settlers may be able to recover from the State is the amount of the purchase price of the land, but nothing for money or time expended, in good faith, upon the land. And while it must be admitted that this amount will not fully satisfy the injury and losses, still it is very difficult for this Commission to suggest a proper remedy and adequate relief.

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EXAMINATION AND APPRAISEMENT OF STATE LANDS.

We do not submit a bill providing for the disposal of our remaining school lands, for the reason that, until an examination and appraisement has been made of these lands, it would be impossible to submit a proper measure having to do with the disposition of lands, the character and value of which are entirely unknown. For that reason we believe that for the next two years these lands should be withheld from sale; that they be examined and determination be made as to what portions thereof should be sold and what portions retained by the State for transfer to the United States in lieu of lands in a compact body which the State might be able to exchange therefor to be used as a State Forest Reserve.

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MINERAL LANDS.

The subject of mining, embracing dredging, oil, placer and quartz locations, presents many complications. In considering the abuses existing in the present mining laws and what is required to rectify such abuses, it is necessary that the opinion of practical miners and mineral experts should be secured. And in furtherance of the Commission's policy first to hear all persons interested, recommendations will be deferred until further hearing and more definite investigations shall have been made. But it should not be forgotten that the Federal Government, rather than the States, has power in such matters.

It has been arranged by this Commission to coöperate with Mr. W. H. Storms, the State Mineralogist, in the preparation of an outline for remedial mining legislation. Meetings with bodies of men representing oil and other mining interests, should be held in the near future, and at these meetings efforts should be made to frame a law which will develop rather than retard the growth of this great industry. An attempt should also be made to discuss all the various methods of the opening and developing of mineral lands. Steps ought also to be taken to protect oil-bearing sands from being flooded with water; to prevent unnecessary waste of natural gas; to provide for the filing of location notice of mineral in the United States Land Office within the district in which such mining location may be situated; to prevent the speculative location of mining claims, and generally to treat upon all matters pertaining to this subject in which the State has any power or influence.

A supplementary report on this project will be submitted for your consideration as soon as these hearings have been held and further investigations made.

GOLD DREDGING.

At the request of the Commission, Dr. Charles B. Lipman, of the U. S. Agricultural Department Experiment Station at Berkeley, very kindly made an examination of the lands around Oroville, California, affected by the gold dredging. Dr. Lipman's report, annexed hereto and marked Exhibit "E" contains the result of his examination into the subject.

Because of a press of other and apparently more important duties, the Conservation Commission has been unable to organize and prosecute a sufficiently thorough and complete investigation of the relation which gold dredging bears to the public welfare to enable it to formulate and regulatory recommendations therefor. The Commissioners have, however, visited the scenes of the dredging operations, and in common with all other persons not directly interested in them, have been unfavorably impressed with the destruction of land produced by these operations.

The Commission has no hesitancy in saying that the State should not

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permit. if it can prevent it, the destruction in any manner, for practically all time, of large areas of agricultural land. It may be true that such destruction will produce more immediate wealth than the continued use, for even centuries, of such lands. But the wealth produced by dredging is not and cannot be so valuable to this State as the even far less wealth annually produced by any agricultural lands ruined by dredging or any other operations.

The dredging operations, it is true, give employment to many men—many more than could be given employment at any one time on the same land if it were retained for agricultural purposes. But gold dredging is ephemeral—it can last but a few years—and when it is finished. the land, being comparatively useless, can give but little or no employment for a very long time. Agricultural land, on the other hand. gives employment practically forever and furnishes not only wealth but the necessities of life to others than those who themselves use it. It is also true that not all the dredgable land is agricultural in character; but a large acreage of it is.

According to Dr. Lipman's report, there are about 20,000 acres of proved dredging ground already in the possession of the dredging companies on the Feather and Yuba rivers; and the companies own something over 12,000 other acres of, as yet, unproved lands.

The question at issue is whether it is of more benefit to the present and future of this State to permit any considerable area of its territory to be ruined and become an eyesore in order that, for a few years, even the enormous sum of over $7,250,000—the output from dredging operations for 1909—shall annually be added to the wealth, not of this State but of this nation. For, although it is true that a great portion of the output of the dredging operations is paid out in this State for labor, supplies and material, it must not be forgotten that the actual profits go largely to other states, and that, when the dredging operations shall have ceased, the production of wealth from the dredged lands will cease. If it shall be deemed advisable to permit 1,000 acres to be ruined, why not 100,000 acres—why not the greater part, the whole, of the State?

HYDRAULIC MINING REGULATED.

The operation of hydraulic mining in this State was regulated because, among other bad results, it was causing the destruction of large areas of agricultural land. The regulation consisted in compelling those who desired to mine by hydraulic power to keep their slickens from falling into and choking the rivers. The result of the hydraulic mining was the annual production of a far greater amount of gold than can be hoped for as the result of dredging operations. The hydraulic mining operations were, nevertheless, regulated, and the regulation was of such a nature as to stop practically all hydraulic mining operations. The consensus of opinion was that, even if the annual production of gold from the hydraulic mines was far greater than the value of the annual products from the agricultural lands the slickens were destroying, it was better public policy to

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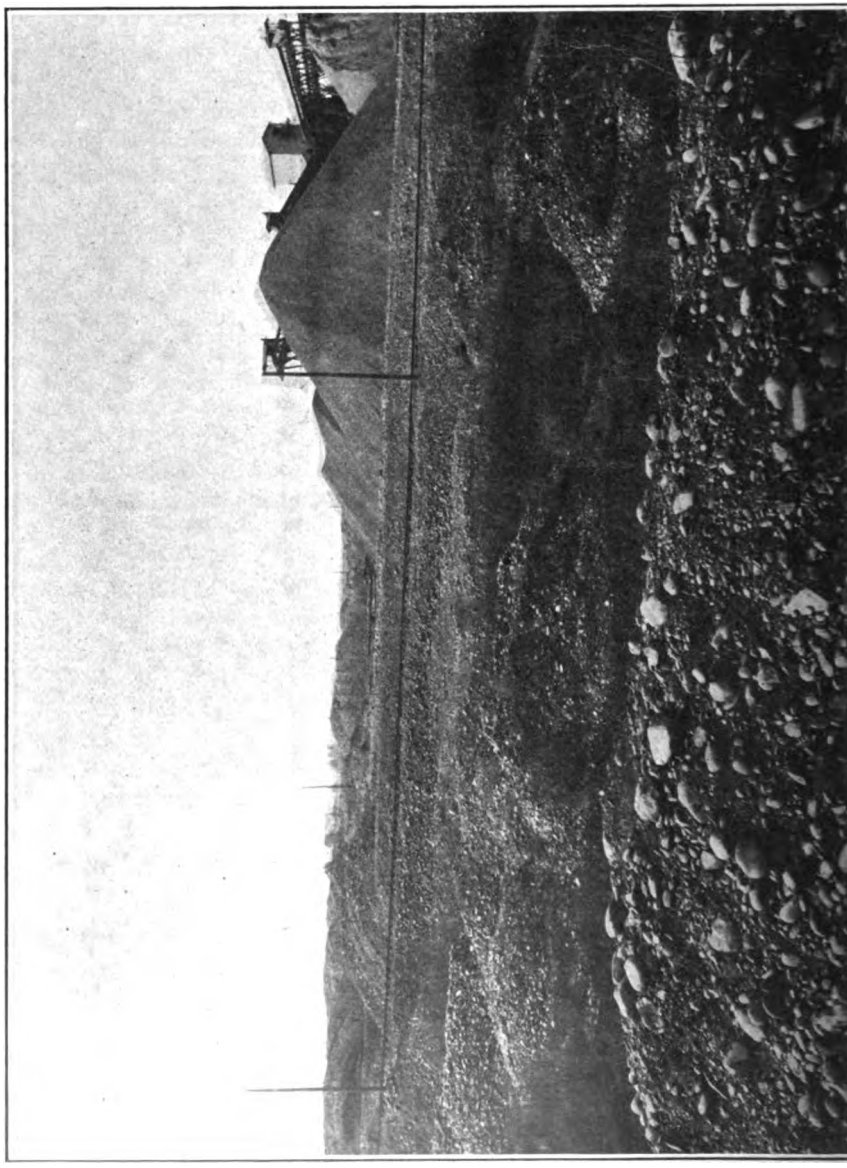

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suspend the hydraulic mining than to permit the destruction of agricultural lands.

DREDGING DESTROYS LAND.

The dredging operations as now conducted turn the land upside down, putting the top soil at the bottom and the bottom cobbles on top of the spoil heaps. The result is, of course, that the productivity of the land is practically destroyed. From observation of the dredging operations, the Conservation Commission is of the opinion that these operations may be conducted in such a way that the material may be run through the dredges and the spoil deposited in such a manner that the soil may be on top and the cobbles at the bottom. It is true that this method would be more expensive than the dredging method now pursued—in many instances it would be prohibitively expensive. But, in the case of the hydraulic mining operations, the question of the expense of methods providing for the preservation of agricultural lands was not considered—the safety sought for being the only consideration involved.

THE ÆSTHETICS INVOLVED.

This question is also one to be considered, in conjunction with that of economics, from the æsthetical standpoint. Is it of sufficient profit to this State to permit the spoliation of large areas of land and the turning of them into hills of unproductive scenery-marring cobblestones? True, even the by-product of cobblestones may be, is, being crushed and used for road material. But are even the profits to the dredges and needed road material to some of the people of this State sufficient to outweigh the damages done in other directions to the present and future generations of California?

REPORT FROM AUSTRALIA.

From "Gold Dredging in California," Bulletin No. 57, issued by the California State Mining Bureau in 1910, page 246 under the heading "Reclaiming Dredged Land," the following quotation is in point:

The following extracts from the papers and reports of the Minister of Mines, New Zealand, John Hayes, inspecting engineer, (page 16 c 3) 'There has been an outcry in some quarters about valuable land being destroyed for agricultural purposes by gold dredging operations. This has undoubtedly been the case in a few instances, but in others, where swampy marsh land has been dredged the effect has been to drain and sweeten it and it is now growing sweet grass and clover where rank sour grass and rushes grew before. At the same time it cannot be claimed that this land has been left in anything like as good a condition as it might have been had advance stripping been practiced, and the soil and subsoil, etc., deposited on the gravel tailing instead of them all being mixed up as at present.'"

No. 2 District A. R. Campbell, inspector:

"An Omeo dredge is making a good show in regard to resoiling, this being mainly attributable to the depth and nature of soil dealt with. This soil is stripped in advance and sluiced down the box with the full body of water, but owing to the tenacity of the material, a fair quantity of it stays on the tailing, the deposit being in some places four feet deep."

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The Commission would, however, suggest that it is entirely within the police power of the State to regulate these dredging operations. It may even be possible to regulate them under the law of nuisances without any further legislative action.

OIL.

The production of natural oil in California was, last year, 84,648,157 barrels, valued at $40,552,088. It, therefore, ranked first in oil production. Oil, being by decision of the courts a mineral, it becomes subject to exploitation only under the provisions of the federal laws. It appears, moreover, that much of the most valuable oil lands in this State were acquired under congressional land grants by the Southern Pacific. But, in express and unmistakable terms, whatever minerals might be found on, in or under these lands were excluded from the deed of gift. The Southern Pacific has, however, proceeded to extract from these lands natural oil and put it to its own use. It has also sold large tracts of these lands to others who have proceeded to take oil therefrom. Such acts on the part of the corporations are apparently in defiance of the law; and those taking oil from such lands, except under the federal laws governing the right to take minerals from public lands, are trespassers on the public domain. The State cannot, of course, take any action to prohibit such acts; that power rests only with the Federal Government, which has brought suit to recover the mineral lands thus acquired by the Southern Pacific.

Complaint is made, by certain of the producers of oil in this State that, because of the acts of certain other producers, water overlying oil sands is permitted to enter and injure those sands and to interfere with the extraction of oil from them. There is already on the statute books of this State a law prohibiting this injury. It is claimed, however, that this law is inoperative. The Conservation Commission recommends that the present law be amended so as to make it operative.

NATURAL GAS.

There are enormous quantities of this very valuable natural resource being unnecessarily wasted in this State. Two years ago, the Legislature passed an act prohibiting the unnecessary wasting of natural gas. But, in spite of the fact that the Conservation Commission called the attention of the district attorneys in the oil-bearing counties to this law, nothing, so far as this Commission has been able to ascertain, has been done to stop this unnecessary wasting of this very valuable natural resource. The value of the gas wasted in 1910 was, according to the statement of Mr. L. M. Aubury, then State Mineralogist, $2,000,000.

The Conservation Commission is strongly of the opinion that the unnecessary wasting of natural gas, especially through abandoned wells, should not be permitted. It is true that, to stop this waste, would require the expenditure of some, but not, in any one case,

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an excessively large sum of money. And, the Commission believes, no person should be permitted to search for or extract our natural resource, oil, in the hope of or to his own profit and, by reason of that hope or its realization, so to conduct his operations as to waste unnecessarily another valuable natural resource, towit, natural gas, even if the prevention of that waste does cost the searcher or the profit-maker some money. The prevention of that waste should be one of the recognized possible costs of all boring of wells, productive or non-productive, in the oil fields of California.

FISH AND GAME.

Fish and game are natural resources of great value, from the standpoint of food supply, and healthful amusement. It is the duty of the State to conserve and preserve these natural resources in every possible way for the benefit of all the people. Proper fish and game laws, strictly enforced, and fish hatcheries and game farms are necessary for this conservation and preservation.

LAKE TAHOE.

Approximately three fourths of the superficial area of Tahoe lie in California—the remaining fourth in Nevada. Its outlet, the Truckee River, begins in California, but soon enters Nevada. On the Truckee River in California are many plants using water power; and there is room for other similar California plants on the river. By means of a tunnel the waters of the lake may be put to power and irrigation use for and in the Sacramento Valley. This lake is also one of California's most beautiful and celebrated spots and places of resort; and, from every standpoint, is one of our most valuable natural resources.

TAHOE SHOULD BE CONSERVED.

California, therefore, should see to it that this lake is conserved for California, at least in the proportion of its water supply that lies within this State. The Conservation Commission is, therefore, very greatly interested in the attempts that have been made and are still being made by the United States Reclamation Service to secure for the Fallon Reclamation Project, in Nevada, a larger portion of the waters of the lake than, naturally and subject to California rights, discharges from it through its natural outlet, the Truckee River.

PLANS OF RECLAMATION SERVICE.

Only a short time ago, the U. S. Reclamation Service endeavored to secure the participancy of the United States Government in a contract with a power corporation, under which contract, by means of a tunnel tapping the lake in Nevada, water was to be taken from the lake, used for power purposes in Nevada and for irrigation purposes on the Fallon project, also in Nevada. Believing that such an arrangement, attempted without consulting the State of California, would be a distinct detriment to the people of this State, the matter was brought

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to the attention of Governor Johnson. The Governor protested vigorously to the President of the United States, and the proposed contract was abandoned. The Reclamation Service it appears, has, however, not ceased its efforts to take and use the waters of the lake on its Nevada reclamation project. It now proposes, it appears, to enter into some sort of an arrangement or contract with the parties claiming ownership of and regulatory powers over the dam at the source of the Truckee River, whereby the amount of water leaving the lake may be regulated for the benefit of the Fallon Project.

THE DAM AT THE SOURCE OF THE TRUCKEE.

The dam at the source of the Truckee was built by private parties under authority of an act of the California Legislature, passed in 1870. This act limited the right of occupancy to twenty years from the date of the proof of the expenditure of $25,000 on construction work. This proof was made in 1875. The right, therefore, expired in 1895. But the State did nothing to take from the persons claiming ownership of the dam the right to maintain and operate it. It appeared, therefore, as if those controlling and operating it might secure, by prescription, perpetual rights to maintain and operate this dam, unless suit were brought to determine the right. The matter was brought to the attention of Attorney General Webb by the California Water Commission and this Conservation Commission. But before he could take action, suit was brought by certain interested private parties in California to have declared terminated the right of those claiming possessory title to the dam. In this suit the Attorney General, representing the State, has intervened.

STATE SHOULD SUE TO HAVE WATERS PARTITIONED.

In the opinion of the Conservation Commission—which is shared by the State Water Commission—the waters of Lake Tahoe are too valuable an asset, from every point of view, to permit them to be diverted, without established limit, into any other state. For, if they be so diverted, it will be difficult, if not impossible, for California to recover her proper share of them. The Conservation Commission, therefore, recommends, as strongly as it can, that this State bring suit, before the Supreme Court of the United States, against the State of Nevada to have the waters of Lake Tahoe equitably apportioned to and between the two states, so that, by prescription or otherwise, the people of California may not be deprived of their present just, legal, equitable, and proper share in the waters of the lake.

STATE SHOULD OWN AND CONTROL DAM.

No private interest should be permitted to own and operate the dam at the source of the Truckee River. Such private ownership and control, paying attention only to the demands for water for its own purposes, will, of course, manipulate the dam with no voluntary regard to the rights and privileges of the owners of littoral lands on the lake or of other parties on the river. The power to do that should not be

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entrusted to any private parties, no matter how benevolent. As above mentioned, the right to maintain and operate the dam expired, by legislative limitation, a long time ago; and, it is believed, the private parties now operating the dam have acquired no prescriptive or other rights to continue to use and operate it. The waters of the lake and the river are used and, in the future, will be still more used by Californians with diverse and adverse interests. These constantly increasing interests should not be at the mercy of any one interest adverse to all the rest. No private person or corporation should be longer permitted to maintain and operate the dam at the source of the Truckee River, with the power to regulate, for its own profit and to the probable detriment of everybody else, the flow of water from the lake and, therefore, the level of the water in the lake.

COMMISSION RECOMMENDS STATE CONTROL OF DAM.

It is true that any person injured or damaged by the act of those in control of the operation of the dam may sue for recovery of compensation for any injury or damage suffered by reason of an improper use of the dam. But the Conservation Commission believes that it is against public policy to permit any private interest to control the operation of a dam by which the level of the waters of the lake can be raised or lowered, to the discomfort, if not the actual injury or damage, of the littoral owners on the lake. Such a power should be only in the hands of the State, the representative of all those having adverse interests on the lake and the river in California. In this way, and in this way only, the Commission believes, can the adverse rights of all persons concerned be best conserved. This Commission, therefore, earnestly recommends that the State take all possible steps for the ousting of the private parties from the control of the dam at the source of the Truckee River, and that it assume the maintenance and operation of the dam.

WASTING OF ARTESIAN WATER.

In some portions of this State flowing wells are permitted to go uncapped, even when the water is not being put to beneficial use. The result is that the underground reservoirs from which these wells derive their supply are depleted and those using water from them in localities above the uncapped wells are deprived of water for irrigation and other purposes. The wasting of water in this manner is an inexcusable act and an economic loss which should not be tolerated. There is on the statute books of this State a law prohibiting this waste. But for some reason or other the district attorneys of the counties in which these wastes are being permitted have taken no steps, so far as this Commission has been able to ascertain, to enforce this very salutary law. Its enforcement is necessary to the public good. The waste is against public policy, unnecessary, easy and cheap of abatement, and an injury to others far removed from the seat of the wastage. The Conservation Commision strongly urges that this law be enforced or amended so that it may and will be enforced.

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IRRIGABLE LANDS IN CALIFORNIA.

Any process by which the fertility of our lands may be increased, or by which non-producing lands may be made productive, is, from the standpoint of the conservation, of the greatest importance.

On account of the small and uncertain rainfall in many and large portions of this State, irrigation is necessary. By means of irrigation large areas have been made far more productive than they were before; large areas of non-productive lands have been made very productive, and there are still other large areas of small-productive and non-productive lands which may, by irrigation, be made largely, even enormously, productive. Parts of southern California, including Imperial County, and the Sacramento and San Joaquin valleys are illustrative of all these conditions. It is not at all a wild statement to say that there is irrigable land enough in this State to accommodate, in plenty and prosperity, a population of 30,000,000 rural people. Nor is it at all beyond the certainties of the future that millions of American families will be raised, in comfort and luxury, on irrigated California farms of five and even less acres. In this manner, the Conservation Commission believes, will be solved, as well as it may be solved, the problem of the drift to the cities of the country population, upon which depends the conservation of human life, comfort, prosperity and happiness.

INVESTIGATION OF IRRIGABLE LANDS.

The Conservation Commission, therefore, deemed it to be its duty, under the provisions of the act creating it, to investigate, as well as it could in the short time at its disposal, the location and area of the irrigable lands of the State and the sources from which those lands may be irrigated. The Commission, therefore, entered into a coöperative agreement with the U. S. Department of Agriculture for the purpose of gathering these data. The results of that agreement are attached hereto in the forms of reports on and maps of the several divisions into which, for the purposes of the investigation, the State was divided. These reports and maps, the Commission believes, are of great value, and will greatly aid the population of areas of California which are now only sparsely, if at all, inhabited.

WEEKS LAW.

On March 1, 1911, Congress passed a law (see Chap. 186, U. S. Stat.) entitled "An act to enable any state to coöperate with any other state or states, or with the United States, for the protection of the watersheds of navigable streams, and to appoint a commission for the acquisition of lands for the purpose of conserving the navigability of navigable rivers."

By this act the sum of two hundred thousand dollars was appropriated "to enable the Secretary of Agriculture to coöperate with any state or group of states, when requested to do so, in the protection from fire of the forested watersheds of navigable streams." The law further

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provides: "That no (such) stipulation or agreement shall be made with any state which has not provided by law for a system of forest fire protection. That in no case shall the amount expended in any state exceed in any fiscal year the amount appropriated by that state for the same purpose during the same fiscal year."

This act is administered, as therein provided, through the Department of Agriculture, but more directly by the United States Forest Service, and all matters connected with the question as to whether or not a state is entitled to the use of any portion of the sum appropriated by said act, are acted upon by the Secretary of Agriculture on the recommendation of the district forestry in the state asking federal aid under this act. Rules and regulations of the department have been framed and promulgated, under which the federal officials act.

RESULT OF "WEEKS LAW" IN OTHER STATES.

The following table sets forth the states which received federal aid under the "Weeks Law" in 1911, the amounts expended under its provisions by the Federal Government in each state, together with the amounts expended by each of the states then receiving federal aid:

State.	State expenditures.	Federal expenditures.	Allotment to states.	Balance of allotment unexpended.
Maine	$23,557 07	$9,991 80	$10,000 00	$8 20
New Hampshire	13,876 21	6,219 50	7,200 00	980 50
Vermont	2,243 90	1,218 00	2,000 00	782 00
Massachusetts	400 12	365 00	1,800 00	1,435 00
Connecticut	513 96	6 00	1,000 00	994 00
New York	3,837 59	2,000 00	2,000 00	
New Jersey	1,241 50	990 00	1,000 00	10 00
Maryland	262 85	261 00	600 00	339 00
Wisconsin	20,841 87	4,437 25	5,000 00	562 75
Minnesota	25,675 77	10,000 00	10,000 00	
Oregon	8,758 89	3,305 00	5,000 00	1,695 00
Totals	$101,209 73	$38,793 55	$45,600 00	$6,806 45

Of the $200,000 appropriated by the U. S. Government for use in the various states, there remained unexpended, on January 1, 1912, the sum of $161,206.45.

The Conservation Commission earnestly recommends that the State, by complying with the provisions of the "Weeks Law" and appropriating at least the sum of $10,000, avail itself of the provisions of that law and thus secure, for forest protection purposes, federal aid to the extent of that sum.

The gist of the "Weeks Law," under which, if the State appropriates money for the protection from fire of watersheds and navigable streams and their tributaries, it will receive from the Federal Government a like sum up to and not to exceed, under the rules of the Secretary of Agriculture, $10,000 per annum, is attached hereto.

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IRRIGATION.

The Commission entered into the following coöperative agreement with the United States Department of Agriculture:

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY.

Agreement Relating to Coöperative Irrigation Investigations.

This Agreement, made and entered into this first day of July, one thousand nine hundred and eleven, by and between the Conservation Commission of the State of California, for and on behalf of the State of California, party of the first part, and the Acting Secretary of Agriculture, for and on behalf of the Department of Agriculture of the United States of America, party of the second part.

WHEREAS, the party of the second part has been conducting irrigation investigations in California during a period of eleven years and has accumulated a large amount of information relating to water, the use of water, and irrigation in said State, and will continue to maintain in said State an expert field force and gather additional information along the same lines during the fiscal year 1912; that is to say, commencing July 1, 1911, and ending June 30, 1912; and

WHEREAS, in an act entitled "An act creating and establishing a commission for investigating and gathering data and information concerning the subjects of forestry, water, the use of water, water power, electricity, electrical and other power, mines and mining, mineral and other lands, dredging, reclamation and irrigation, and for revising, systematizing and reforming the laws of this State upon, concerning, regarding, or appertaining to these said subjects; providing for the appointment of said commission to be known as the 'Conservation Commission of the State of California;' prescribing the powers and duties of said commission and its members, and providing for the expenses of said commission and appropriating money therefor," approved April 8, 1911, the legislature of California has created a Conservation Commission for the purpose of investigating and gathering data and information regarding, among other things, the subjects of water, the use of water, and irrigation, and said Conservation Commission desires to present promptly to the people and legislature of California full information on water, the use of water, and irrigation in said State, as provided in said act; and

WHEREAS, the party of the second part desires to extend and enlarge its investigations of the water and irrigation conditions and possibilities in the State of California, as related to agricultural development; and

WHEREAS, the party of the first part is desirous of having the party of the second part aid said party of the first part in gathering data and information concerning irrigation in the State of California with a view to enabling the party of the first part to make full, accurate and complete reports thereon, and the party of the second part wishing to assist the party of the first part in conducting such work with a view of enabling the party of the second part to extend, enlarge and complete the irrigation investigations which said party is conducting relative to making reports on the present extent and future possibilities of irrigation in California and the prompt preparation of such reports in form for publication, using therefor such data and information as are now in possession of the party of the second part, or that may be collected by said party of the second part during the existence of this agreement; now, therefore,

This Agreement Witnesseth:

First. The party of the first part, for and in consideration of the promises and agreements of the party of the second part, well and faithfully executed in the manner as hereinbefore provided, does hereby promise and agree with the party of the second part as follows:

1. To coöperate with the party of the second part in gathering data and preparing a report on water, the use of water, and irrigation with particular reference to the present extent and future possibility of irrigation in California.

2. To contribute to the expenses incurred in gathering the data and preparing the reports as provided for in this agreement during the period commencing with the first day of July, one thousand nine hundred and eleven, and ending the thirtieth day of June, one thousand nine hundred and twelve, a sum not to exceed ten thousand

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dollars ($10,000.00), including salaries, and expenses of travel and subsistence, when the same are authorized by the party of the second part, or the representative of said party by the party of the first part; provided, that all moneys paid by the party of the first part hereunder shall be used for the specific purposes set forth in this agreement, and that the investigations made and the reports prepared hereunder shall be in addition to the investigations made and reports prepared and published under the coöperative agreement existing between the party of the second part and the Engineering Department of the State of California. All claims for expenses incurred and work performed by said employees shall, from time to time, be presented and filed with the party of the first part, audited, and, if found correct, approved by the party of the first part.

Second. The party of the second part, for and in consideration of the promises and agreements of the party of the first part, well and faithfully executed in the manner as herein provided, does hereby promise and agree with the party of the first part as follows:

1. To extend and enlarge the investigations which said party is conducting during the fiscal year 1912, beginning July 1, 1911, and ending June 30, 1912, for the purpose of determining the present extent and future possibilities of irrigation in California and for preparing reports thereon in such manner as to set forth what the present extent and future possibilities of irrigation in California are, including, (*a*) a statement of the water supply of California, both surface and underground, available for irrigation; (*b*) a statement of the extent, character, and location of the agricultural areas susceptible of and adapted to irrigation; (*c*) a statement of the present extent of irrigation in California; (*d*) a statement of the extent and location of the unused waters available for irrigation extension, and (*e*) an irrigation map of California.

2. To contribute to the expense of the above-mentioned investigation and reports from the moneys appropriated by Congress for "Irrigation Investigations," 1912, during the period from the first day of July, one thousand nine hundred and eleven, to and including the thirtieth day of June, one thousand nine hundred and twelve, the sum of one thousand dollars ($1,000.00), in addition to any moneys expended by the party of the second part under the coöperative agreement entered into by said party with the Engineering Department of the State of California; including the salaries of employees, expenses of travel and subsistence, when the same are authorized by the Secretary of Agriculture, and the cost of preparing, illustrating, and printing the above-mentioned reports.

Third. It is mutually understood and agreed by and between the parties hereto as follows:

1. That in the event that any question shall arise between the parties hereto as to the meaning of this instrument, the provisions of said act of the legislature of the State of California, approved April 8, 1911, hereinbefore referred to, as far as applicable, shall control.

2. That the Secretary of Agriculture may, from time to time, delegate to any officer or person in the employ of the United States Department of Agriculture, with the same effect as if such officer or employee were specifically named herein, every right and power hereby conferred upon the said Secretary of Agriculture, and until the party of the first part shall be advised in writing to the contrary, every right and power conferred upon the said Secretary of Agriculture shall be deemed to be delegated to the Director of the Office of Experiment Stations, of the United States Department of Agriculture, or the representative of said Director.

3. That such complete typewritten reports of the investigations carried on under this agreement as shall be made shall be filed from time to time with the Conservation Commission of the State of California as may be required by said Commission.

4. That the results of the coöperative work are to be the joint property of the parties hereto and either of the parties may publish such results, provided proper credit be given to the other party for its part in the work, and provided further, that any matter to be published by either party be submitted to the other party before publication.

5. That this agreement shall take effect on the first day of July, one thousand nine hundred and eleven, and shall expire on the thirtieth day of June, one thousand nine hundred and twelve.

6. That this contract shall not be assigned in whole or in part; that no Member of or Delegate to Congress, or Resident Commissioner, after his election or appointment, and either before or after he has qualified and during his continuance in office, and no officer, agent, or employee of the Government, shall be admitted to any share or part of this contract or agreement, or to any benefit to arise thereupon; and that

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no convict labor shall be employed in carrying out the terms of this agreement, in accordance with executive order signed May 18, 1905. Nothing, however, herein contained shall be construed to extend to any incorporated company, where such contract or agreement is made for the general benefit of such incorporation or company (section 3741, Revised Statutes, and sections 114-116, act of March 4, 1909).

In Testimony Whereof, the parties hereto have executed this agreement on the day, month and year first above written.

CONSERVATION COMMISSION OF THE STATE OF CALIFORNIA.
(Signed) GEO. C. PARDEE,
Party of the first part.
(Signed) W. W. HAYS,
Acting Secretary of Agriculture,
Party of the second part.

In accordance with this agreement, the Department has furnished us with reports showing the result of this investigation to date. The following letters of transmittal and submission explain the field covered by the coöperative agreement and outline additional reports in preparation:

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS.
WASHINGTON, D. C., October 15, 1912.

HON. GEO. C. PARDEE, *Chairman*,
Conservation Commission of the State of California,
Sacramento, California.

SIR:

I transmit herewith three reports on the irrigation resources of California, prepared under the supervision of Samuel Fortier, Chief of Irrigation Investigations of this office, by Mr. Frank Adams, in charge of the irrigation investigations of this office in California, and his collaborators, S. T. Harding, R. D. Robertson, and C. E. Tait, in accordance with a coöperative agreement between the Secretary of Agriculture and your Commisssion, dated July 1, 1912, which makes the results of the work the joint property of the Department and your Commission.

Respectfully,
(Signed) A. C. TRUE, Director.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF EXPERIMENT STATIONS,
IRRIGATION INVESTIGATIONS.
WASHINGTON, D. C., October 15, 1912.

DR. A. C. TRUE,
Director, Office of Experiment Stations,
Department of Agriculture.

SIR:

Herewith are transmitted three reports on the irrigation resources of northern, central, and southern California, prepared in accordance with the coöperative agreement between the Secretary of Agriculture and the Conservation Commission of California, dated July 1, 1911. Accompanying the reports are three irrigation maps, also covering the northern, central, and southern portions of the State.

It is recommended that these reports and maps be forwarded to the Conservation Commission in accordance with the clause in the above-mentioned coöperative agreement making the results of the investigations the joint property of the Department and the Commission.

In presenting these reports covering a portion of the work carried on, it is not intended to submit a complete engineering or agricultural discussion of the extensive land and water resources of California, but rather what might be termed preliminary

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reconnaissance reports that will give to the people of California generally a clear outline of irrigation conditions and possibilities in each agricultural area of the State.

The methods and scope of the field investigations are indicated in the preliminary pages of the report on northern California. Each valley agricultural area in the State, with the possible exception of very small and unimportant isolated areas in the mountains, has been visited and mapped to show the valleys, plains, and foothill-belt areas, the lands now irrigated, and the principal irrigation canals, the mapping being based on reconnaissance observation rather than on exact surveys.

In addition to the reports and maps submitted herewith, this office has at hand more detailed reports, with maps, dealing with present irrigation development in six typical sections of the State, viz: Shasta Valley, the Sacramento Valley areas to which Feather River is tributary, the valley of San Joaquin River and tributaries, the portion of Santa Clara Valley, in Santa Clara County, watered by Los Gatos, Guadalupe, and Campbell creeks; the valley of Santa Clara River, in Ventura County; and the valley of Santa Ana River, in San Bernardino, Riverside, and Orange counties.

It is our intention, in accordance with our understanding with the Commission, to prepare a publication summarizing these detailed reports and also summarizing the three reports on irrigation resources transmitted herewith for publication by the Conservation Commission. This summary report will carry also the full irrigation map of the State and the more detailed maps of the six typical sections referred to above.

In submitting our various reports of work done in coöperation with the Conservation Commission it is due that we give credit to the State Engineering Department of California for data used in these reports that have been gathered at the joint expense of that Department and this office during the past ten years; to the United States Bureau of the Census, with whom we coöperateed in taking the irrigation census of California; and to the following field agents, Harry Barnes, S. H. Beckett, R. W. Broadie, J. N. Irving, J. T. Kingdon, J. C. Marr, R. V. Meikle, F. W. Stanley, E. W. Stanton, Jr., N. M. Stover, A. J. Salisbury, Jr., and S. C. Whipple.

Respectfully,

(Signed) SAMUEL FORTIER.
Chief of Irrigation Investigations.

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IRRIGATION RESOURCES OF NORTHERN CALIFORNIA.

By FRANK ADAMS,
Irrigation Manager in Charge of Irrigation Investigations in California.

INTRODUCTION.

This is the first of three reports giving the more detailed results of an investigation into the irrigation resources of California made by the U. S. Department of Agriculture, under coöperative agreement with the Conservation Commission of the State of California.

The ground sought to be covered in this investigation was (1) a study of the water supply of California available for irrigation; (2) a statement of the extent, character, and location of the agricultural areas susceptible of and adapted to irrigation; (3) a statement of the present extent of irrigation in California; and (4) a general statement of the extent and location of the unused waters available for irrigation. In connection with this study it was also proposed to prepare an irrigation map of California.

For the prosecution of this investigation a fund of $10,000 was set aside by the Conservation Commission and about $4,000 was allotted by the U. S. Department of Agriculture. This small fund was obviously inadequate to make an exhaustive engineering and agricultural study of the irrigation resources of California. It was thought to be sufficient, however, by making use of available published and unpublished data, for showing with substantial accuracy such essential features regarding irrigation development and possibilities in California as are necessary to give the general public a clearer idea than they have heretofore had of the importance of enacting better irrigation laws.

The State of California covers an approximate area of one hundred million acres and occupies a north and south distance of over seven hundred miles. For these reasons and because of the diversity of conditions it is not convenient to present the results of the entire study in as much detail as is desired in a single report. This report, therefore, deals with northern California alone, which is taken to be that portion of the State north of San Francisco, San Pablo, and Suisun bays, and the southern boundaries of Sacramento and Amador counties. Further reports follow in sequence covering the irrigation resources of central and southern California. A fourth report is being prepared that summarizes the results obtained for the whole State and treats in more detail of the character of the present use of water for irrigation, in accordance with a second agreement with the Conservation Commission entered into early in 1912.

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PREVIOUS INVESTIGATIONS.

California has long been a field of scientific agricultural investigation, so that the main agricultural characteristics of the State are well known. In 1880 Mr. Wm. Ham Hall, state engineer, issued as part of his first report, a report on the irrigation of the plains in which questions of both land and water were treated exhaustively in the light of physical data and knowledge of irrigation then available.[1] Annual and special reports of the California Agricultural Experiment Station have considered questions of soils, alkali, crops, waters, and culture methods from the standpoint of irrigation development. In 1883, Dr. E. W. Hilgard, until recent years director of the station, submitted to the superintendent of the census a treatise on the agricultural features of California, with an agricultural map, that outlined the various agricultural zones of the State and described both their physico-geographical and main soil features.[2] For many years the United States Geological Survey has been mapping topography, measuring streams, and studying underground waters in California, and for several years the United States Reclamation Service had engineers in the field looking for possibilities for development under the reclamation act. Since 1900 the Office of Experiment Stations, U. S. Department of Agriculture has been prosecuting irrigation investigations in California, since 1903 in coöperation with the State, and numerous bulletins giving results of these investigations have been published from time to time.[3] In addition, during 1910 and 1911, the Office of Experiment Stations took a full irrigation census of California under coöperative agreement with the Bureau of the Census, this census covering not only acreages and costs, but also the more general features of irrigation development. Thus the investigation into irrigation resources with which this and the succeeding reports deal had as a starting point a large mass of known data without which the work would not have been possible within the limits of time and money available under the agreement with the Conservation Commission.

PLAN OF FIELD WORK.

Irrigation is not equally necessary or equally advantageous all over California, nor is it possible to determine either its necessity or its advantage wholly by rainfall. If general grain farming were the highest use to which the soils of the State could be put, but little irrigation development would be found either now or in the future in the coast or interior valleys north of Sacramento or Stockton. But from these points southward, the degree of irrigation necessity would increase

[1] Report of the State Engineer to the Legislature of California, Session of 1880.

[2] U. S. Int. Dept., Census Office, Report on the physical and agricultural features of the State of California, by E. W. Hilgard, Ph.D., 1884.

[3] See chiefly U. S. Dept. Agr., Office Expt. Stas. Buls. 100, 119, 133, 153, 207, 236, 237, 239; Senate Doc. 246, 60th Cong., 1st Sess.

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toward the southern boundary, becoming absolute in the lower San Joaquin and in most of the agricultural territory south of Tehachapi. If, however, it were not for the fact that, except in the mountain valleys, the California winter is a growing period, even the northern third of the State would not grow large annual crops without irrigation, because rainfall in California comes mostly from November to April, followed by the well-known California rainless summer, during which few plants could be both germinated and brought to maturity without artificial moisture. On the other hand, it is the rainless summers that make irrigation either a necessity or a marked advantage in nearly every section of the State, and which prevent disregarding any section in a state-wide irrigation survey.

The climatic and other agricultural features of California being so variant in their effect on irrigation requirements and practices, the most practicable way of treating the irrigation resources is by what might be termed irrigation zones, within which both present irrigation practice and probable future irrigation needs are generally the same. Six such zones or divisions, following county lines where convenient and topography rather than hydrography, were accordingly assumed for northern California, as follows: The northern coastal counties, including the bay and coast counties north of San Francisco and also Lake County; the northcentral mountain valleys, including Siskiyou and Trinity counties, Shasta County north of Pit River, and the portion of eastern Lassen County that lies in Fall River Valley; the northeastern plateaus and valleys, including Modoc and Lassen counties except the part of Fall River Valley lying in Lassen County, and Mountain Meadows, west of the main range, in Lassen County; the upper Sierra or Feather River valleys, including Mountain Meadows in Lassen County and the valleys in Plumas and Sierra counties, all of which lie in the upper Feather River drainage; the Sierra foothills, below an elevation of 2,500 feet and above the plains of Sacramento Valley; and Sacramento Valley.

Platting agricultural areas—This involved a reconnaissance of each area to determine the main questions as to its location, approximate acreage, and general soil and agricultural features. In this reconnaissance only areas of importance from the standpoint of irrigation were considered; that is, only those areas lying within the general belts of available water supplies and where irrigation is needed or would prove beneficial. All valley areas were sought to be visitd, even though, as on the immediate coast, water may not now be used, or, as on the deserts, no irrigation is now practiced or immediately likely on account of an absence of a water supply. Rolling and broken mountain areas were included only as they are within range of water for irrigation, as the plateaus of Modoc and Lassen counties and the foothills of the western Sierra Nevada. Further standards were that the areas should be irrigable, cultivable, and capable of producing agricultural crops, that they should not be forested with merchantable timber and there-

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fore at present more valuable for forests than for agriculture, and that where wooded and rolling they should at least be similar in character to nearby areas that are being cultivated and irrigated. Thus an attempt was made to consider all agricultural lands in the State that are topographically irrigable and within reasonable reach of water supply for irrigation; yet where the lands exceeded in acreage the areas for which there is water for irrigation, no endeavor was made to indicate the particular areas on which the available water is most likely to be used and which, in a very strict sense, might therefore be termed the only irrigable areas of the State. The outlines of the areas are based on careful field inspection and not on instrument surveys. In some cases, particularly of the Sierra foothills and the foothill and valley plains of Sacramento Valley, the absence of distinct differences made the choice of where the outlines should be run to some degree a matter of the personal judgment of the agent. But where doubt existed as to their proper location for important areas, careful inspection was made with a view to such revision as might be found necessary. Therefore, the agricultural areas as shown on the accompanying map are believed to be substantially correct, yet the map should in no case be considered as drawing the line between agricultural and non-agricultural land on individual holdings.

Platting irrigated areas—This was done in connection with the reconnaissance of agricultural areas but was based chiefly on the irrigation census. In case of important areas, the data were revised to 1911 and under the larger canals in Sacramento Valley to 1912, inclusive. Areas irrigated by small private ditches or small private pumping plants have been platted to the nearest section where such section is shown by the census returns or where it has been otherwise possible to locate such areas with reasonable certainty. Areas under small private systems for which the location could not be ascertained in this way have been omitted from the map but are included in the tabular summaries in this report.

Water supply—General data regarding the water sources available to the various areas have been obtained in the field in connection with the reconnaissance of those areas for determining their location, extent, and agricultural characteristics. Stream-flow data have been chiefly obtained from the records of the California State Engineering Department from 1878 to 1884[1] and from those of the United States Geological Survey for the years since then down to 1910, inclusive.[2] Occasional records have been taken from more recent gagings by the Geological Survey or by this Office in coöperation with it. For probable run-off where no records of public or private gagings have been at hand, conservative estimates have been made on a basis of rainfall, provided available data have warranted such procedure. Data regarding known

[1]Cal. Engineering Dept., Physical Data and Statistics. Wm. Hall, state engineer, 1886.

[2]Summarized in U. S. Geol. Survey Water Supply Papers Nos. 298 and 300.

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storage have come mainly from the reports of the United States Reclamation Service and from the reports of water-supply investigations of the city of San Francisco. Other sources have, however, been drawn on as indicated. No opportunity has been afforded for searching out reservoir sites by field investigation. For northern California conclusions regarding underground supplies are based on data regarding irrigation wells reported to 1910, inclusive, by the irrigation census.

SUMMARY OF AGRICULTURAL AND IRRIGATED AREAS.

The concluding pages of this report summarize the data that have been gathered as to the irrigation resources of northern California, but the following preliminary summary will indicate in advance the relative areas in the six different irrigation zones that have been assumed for northern California:

Summary of agricultural and irrigated areas in northern California.

Division.	Valley agricultural land. Acres.	Valley plains. Acres.	Foothill agricultural land. Acres.	Areas irrigated. Acres.
Northern coastal counties	503,000			2,290
North central mountain valleys	435,000			99,910
Northeastern plateaus and valleys	867,000			161,850
Feather River valleys	158,000			50,600
Sierra foothills			789,000	45,250
Sacramento Valley	2,659,000	790,000		123,800
Total	4,622,000	790,000	789,000	483,700

NORTHERN COASTAL COUNTIES.

The seven counties embraced within this division or zone have been generally considered as not requiring irrigation. For the extreme northern coast, as above Cape Mendocino, such is undoubtedly the case, as it is also for the remainder of the division if absolute necessity is meant, or if the crops grown are perennial and deep-rooting. But away from the coast, rainless summers are as much a fact here as elsewhere in the State, and for such crops as alfalfa and summer-growing annuals, irrigation grades from a distinct advantage to almost a necessity. The growth and yield of even orchards and vineyards when on shallow and non-retentive soil can also undoubtedly be increased by irrigation water where topography and supply permit its application. It can safely be predicted that throughout this entire division, excepting along the immediate coast, every drop of water that can be put on to land will eventually be used in irrigation.

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Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin.

Area.	County.	Valley agricultural land, acres.	Area irrigated, acres.	Principal water sources for irrigation.
Smith River Valley and adjacent coastal lands	Del Norte	36,000	0	Smith River; supply ample.[1]
Lower Klamath River	Del Norte	8,000	0	Klamath River; supply ample.[1]
Upper Klamath and tributaries	Humboldt	300	100	Klamath River and tributaries; supply ample.
Prairie Creek	Humboldt	700	-------	Prairie Creek; supply ample.[1]
Orick	Humboldt	1,300	-------	Redwood Creek; supply ample.[1]
Big, Stone, and Freshwater lagoons	Humboldt	1,800	-------	Lagoons south of Orick; supply ample.[1]
Hupa Valley	Humboldt	6,800	-------	Trinity River; supply ample.
Little River	Humboldt	2,400	150	Little River; supply ample.[1]
Essex	Humboldt	700	-------	Mad River; supply ample.[1]
Upper Mad River, scattering	Humboldt	1,000	-------	Mad River and tributaries; supply ample.
Mad River bottoms	Humboldt	6,200	-------	Mad River; supply ample.[1]
Arcata Bottoms	Humboldt	11,500	0	Mad River and Jacoby and Freshwater creeks; supply ample.[1]
Lower Humboldt Bay drainage	Humboldt	5,900	0	Elk River and Salmon creeks; supply ample.[1]
Kneeland Prairie	Humboldt	9,500	0	None readily accessible.
Maple Creek	Humboldt	600	0	Maple Creek; supply ample.[1]
Eel River Valley	Humboldt	42,000	0	Eel River; supply ample.[1]
Elinor	Humboldt	500	0	Eel River and small tributaries; supply ample, mainly by pumping.[1]
Pepperwood	Humboldt	800	0	Eel River and small tributaries; supply ample, mainly by pumping.[1]
Shively	Humboldt	600	-------	Eel River and small tributaries; supply ample, mainly by pumping.[1]
Englewood	Humboldt	300	-------	Eel River and small tributaries; supply ample, mainly by pumping.[1]
Myers	Humboldt	300	50	South Fork Eel River; supply ample by pumping.
Miranda	Humboldt	300	-------	South Fork Eel River; supply ample by pumping.
Phillipsville	Humboldt	300	-------	South Fork Eel River; supply ample by pumping.
Fort Seward	Humboldt	600	-------	South Fork Eel River; supply ample by pumping.
Garberville	Humboldt	1,300	-------	South Fork Eel River; supply ample by pumping.
Van Duzen River, scattering	Humboldt	2,500	25	Van Duzen River; supply ample.
Capetown	Humboldt	1,900	0	Bear River; supply ample.[1]

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Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin—Continued.

Area.	County.	Valley agricultural land, acres.	Area irrigated, acres.	Principal water sources for irrigation.
Petrolia	Humboldt	800	35	Mattole River and tributaries; supply ample.[1]
Upper Mattole Valley	Humboldt	4,300	0	Mattole River and tributaries; supply ample if storage is feasible.
Humboldt County, scattering	Humboldt		6	
Long Valley	Mendocino	4,400	60	Long Valley Creek; supply ample if storage is feasible.
Round Valley	Mendocino	18,400	20	Middle Fork Eel River and underground; supply ample; some drainage necessary.
Williams Valley	Mendocino	1,000	0	Run-off from 11 square miles of tributary watershed.
Willits Valley	Mendocino	8,000	10	Small creeks and probably underground; supply probably ample; much drainage needed.
Walker Valley	Mendocino	1,500	60	Walker Valley Creek and springs; run-off with storage probably ample.
Potter Valley	Mendocino	7,000	100	70 square miles of watershed on East Fork of Russian River; tunnel diversion from South Eel River and pumping; supply ample.
Redwood Valley	Mendocino	4,000	10	80 square miles of watershed on West Fork of Russian River and probably underground; supply present for at least considerable area.
Coyote Valley	Mendocino	3,800	10	80 square miles of watershed on East Fork of Russian River, South Eel River, and pumping.
Ukiah Valley	Mendocino	15,000	160	250 square miles of watershed on Russian River, tunnel diversion from South Eel River, and pumping; supply ample.
Sanel Valley	Mendocino	5,000	0	Russian River by pumping.
Anderson Valley	Mendocino	5,600	25	Pumping from Navarro River and tributaries.
Garcia River Valley	Mendocino	1,800	0	Garcia River.[1]
Mendocino County, scattering	Mendocino		92	
Russian River Valley	Sonoma	35,000	200	Russian River, tunnel diversion from South Eel River, and pumping; with full development supply ample for area likely to be irrigated.

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Dry Creek Valley	Sonoma	8,000	20	100 square miles of watershed producing mostly torrential flow; some pumping.
Santa Rosa Valley	Sonoma	90,000	60	Santa Rosa, Mark West, and Petaluma creeks are perennial, but give small summer flow; underground water available in some cases where needed.
Knights Valley	Sonoma	2,500	13	10 square miles of local watershed.
Los Guilicos Valley	Sonoma	16,000	15	50 square miles of watershed would give partial supply if storage is available.
Sonoma Valley	Sonoma	23,000	344	80 square miles of watershed with storage required; artesian flow near Sonoma; supply inadequate for full irrigation.
Gravelly Valley	Lake	500	5	Proposed reservoir site.
Upper Lake	Lake	6,200	0	Middle Creek with 67 square miles of watershed of typical coast range topography above Clear Lake; average annual run-off is 770 acre-feet per square mile.
Bachelor Valley	Lake	1,900	0	13 square miles of local watershed.
West Lake Valley	Lake	1,100	0	Small local drainage and pumping from Clear Lake.
Scotts Valley	Lake	4,200	25	77 square miles of watershed; some artesian supply.
Big Valley	Lake	11,000	280	Kelsey Creek with 120 square miles of rough drainage yielding a large torrential run-off; reservoir reported privately surveyed with capacity of 27,500 acre-feet; supply should be ample if all conserved.
Long Valley	Lake	2,600	0	Long Valley Creek with about 40 square miles of watershed.
Little Indian Valley	Lake	1,400	24	North Fork of Cache Creek. Little Indian Valley on this stream has been considered as a reservoir site, the United States Reclamation Service estimating that 110 square miles of watershed will produce 50,000 acre-feet annually.[2]
High Valley	Lake	2,000	0	8 square miles of local watershed.
Burns Valley	Lake	900	0	Possibly minor storage and pumping from Clear Lake.
Lower Lake	Lake	1,700	31	9 square miles of local watershed and pumping from Clear Lake.
Morgan Valley	Lake	1,700	0	10 square miles of local watershed, insufficient without underground supply.

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Summary of valley agricultural and irrigated areas in northern coastal counties of Del Norte, Humboldt, Mendocino, Sonoma, Lake, Napa, and Marin—Continued.

Area.	County.	Valley agricultural land, acres.	Area irrigated, acres.	Principal water sources for irrigation.
Cobb Valley	Lake	400	50	10 square miles of local watershed on upper Kelsey Creek.
Coyote Valley	Lake	4,800	65	Putah Creek; supply ample if available; United States Reclamation Service estimates 80,000 acre-feet available for storage.[2]
Middletown	Lake	6,600	142	Putah Creek drainage; supply ample if available, although storage necessary.
Napa Valley	Napa	42,800	311	Napa River and Conn, Sarco, Milliken, Dry, and White Sulphur creeks would give all needed with storage; tributary watershed of 235 square miles with light summer flow; underground supply uncertain.
Berryessa Valley	Napa	10,000	130	550 square miles of Putah Creek drainage with storage would supply water needed if legally available.
Capell Valley	Napa	700	0	16 square miles of local watershed on Capell Creek.
Foss Valley	Napa	400	0	10 square miles of local watershed.
Wooden Valley	Napa	1,100	0	8 square miles of local storage tributary to Suisun Creek.
Gordon Valley	Napa	1,000	0	18 square miles of local watershed.
Marin County, scattering	Marin	----------	67	
Totals		503,000	2,293	

[1]Little irrigation likely; see text.
[2]U. S. Reclamation Service, 5th Annual Report.

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As shown in the accompanying tabular summary, although numerous, none of the valley agricultural areas in this division are large compared with the principal areas elsewhere in the State. The three northern coast counties comprise an important redwood belt, and particularly in Del Norte and Humboldt, almost the sole agricultural industries are dairying and stockraising. From Russian River Valley in Mendocino County north to southern Humboldt, stockraising predominates, while in the remainder of the division, particularly about Ukiah, Cloverdale, Geyserville, Healdsburg, Santa Rosa, and Sebastopol, in Mendocino and Sonoma counties, Kelseyville, in Lake County, and throughout Napa Valley the more intensified culture associated with orchard and vineyard growing leads. Here, although some orchards on the drier land will be irrigated as the benefits of irrigation are more thoroughly appreciated, as well as farther north the main use of water will be on alfalfa, small fruits, and truck.

The water resources of this division are less utilized than are those of any other similar area in California. Due to this fact there have been less investigation and measurement of their quantity. The upper drainage of Cache and Putah creeks in Lake County has been measured for proposed use in Sacramento Valley, but except for Klamath River, in Oregon, no gaging stations have been maintained by the United States Geological Survey on any of the coast streams in this division prior to 1910.[1] It is known, however, that the flow of Smith, Klamath, Trinity, Mad, lower Eel, Mattole, and the other principal streams in Del Norte and Humboldt counties is considerably more than will ever be required in irrigation, owing to the small areas of agricultural land bordering them and lying away from the coast. As a rule, the smaller streams in these two counties will be of most importance, because most easy to put on the irrigable land, and because the crops that can be raised under irrigation generally will not yet justify the cost of lifting water from the lower beds of the large streams. No measurements are at hand for these smaller streams, but in most cases their flow is ample for the small areas within their reach. In Mendocino, Sonoma, Lake, and Napa counties, the water supply is less abundant and the areas of agricultural land larger. There the most important streams from an irrigation standpoint are Russian River, reinforced by tunnel diversion from South Eel River north of Potter Valley, Kelsey Creek, and Napa River. Proposed increased diversion from South Eel River into Russian River will if carried out have an important bearing on irrigation development in Russian River Valley and nearby areas. Involved with this is the proposed storage in Gravelly Valley, Lake County, of 200,000 acre-feet of water, Gravelly Valley reservoir site having a tributary watershed of 240 square miles. The

[1] In the fall of 1910 or the fall of 1911 gaging stations were established by the Geological Survey in this division as follows: Middle, North, and South forks Smith River, near Crescent City; Redwood Creek, near Korbel and near Orick; Mad River, near Arcata; Eel River, near Scotia; Van Duzen River, near Bridgeville; Yager Creek, near Carlotta; South Fork Eel River, near Garberville; Middle Fork Eel River, near Covelo; South Eel River, near Hearst; Russian River and East Fork, near Ukiah; Russian River, near Geyserville.

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generation of power in connection with the diversion from South Eel River is part of the development under way, and as the use of the water in Russian River, Potter, and neighboring valleys will be largely by pumping, the power features can be made an important adjunct.

In Napa County, irrigation conditions are somewhat similar to those in Russian River Valley, although rainfall on the agricultural portions is somewhat less and the expense of supplying irrigation water greater. The successful growth of crops without water here as elsewhere in this division has diverted attention from the benefits of irrigation.

The main irrigable valley in Lake County is Big Valley, south of Lakeport. Storage on Kelsey Creek and the possible pumping from Clear Lake, if legally feasible, for the lands lying close to Clear Lake, must furnish the water supply. Cache Creek, which is the outlet of Clear Lake, and Putah Creek, which also rises in Lake County, are or will be utilized in Sacramento Valley and are therefore not part of the irrigation supply of this division.

There are few present uses of water in the northern coastal counties division adverse to irrigation, chiefly because but little use of the coast streams has yet been made. Due to lack of local development furnishing a market for power, the more available streams of the Sierra Nevada have rather been drawn on to supply the general market.

There is a total of 503,000 acres of valley agricultural land reported in this division, of which but 2,293 acres is now irrigated. Only the run off from Lake County can be used after leaving this division. Taken as a whole, the division, which has a total area of 12,700 square miles, and a normal precipitation of 25 to 90 inches, receives far more water than can ever be utilized. Eliminating Del Norte County and the immediate coast areas of Humboldt, Mendocino, Sonoma, and Marin counties, the area of irrigable agricultural land is substantially 380,000 acres. Probably not over 100,000 acres will ever be watered.

NORTH CENTRAL MOUNTAIN VALLEYS.

That portion of California between the northern end of Sacramento Valley and the Oregon line, and extending from the lava plateaus of Modoc and Lassen counties on the east to the coast counties of Humboldt and Del Norte on the west, comprise what is conveniently classified as the north central mountainous division of the State. Within this division are the counties of Siskiyou and Trinity, Shasta County above the junction of the Sacramento with the Pit, and a small portion of Lassen County included in Fall River Valley about Pittville. The northern half of the division, comprising Siskiyou County, and extending from Mt. Shasta and the Scott and Trinity mountains to Oregon, is within the Klamath drainage. Trinity County is almost wholly within the drainage of Trinity River, which in turn empties into the Klamath in northern Humboldt.

Speaking generally, this diviison is an intermountain region of relatively backward irrigation development. While scattered over four

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counties, the agricultural areas are mainly similar in conditions; they range in elevation from 2,000 to 4,000 feet, generally have a rainfall of less than 20 inches, are surrounded by forest or mining interests, and are devoted mainly to crops associated with stock-raising. The valleys, although already generally prosperous, are capable of a considerable advancement, but this must be conditional on a more modern irrigation system and less wasteful irrigation practice. While the need for irrigation is generally recognized and most of the water in immediate proximity to the irrigable land is claimed and supposedly put to use, yet that use is far less economical than would be required under a public irrigation policy that would look to the most complete utilization possible.

SUMMARY OF VALLEY AGRICULTURAL AND IRRIGATED AREAS.

The following tabular summary groups the northcentral mountain valleys by counties and gives the acreages of valley agricultural and irrigated land in each:

Summary of valley agricultural and irrigated areas in north central mountain valleys.

Area.	County or counties.	Valley agricultural land. Acres.	Areas irrigated. Acres.
Lower Klamath Lake	Siskiyou	23,000	4,600
Butte Valley	Siskiyou	65,000	2,800
Klamath River above Salmon River	Siskiyou	23,000	8,900
Shasta Valley	Siskiyou	158,000	23,800
Scott Valley	Siskiyou	55,500	15,500
Fall River Valley	Shasta and Lassen	66,000	24,700
Salmon River and tributaries	Siskiyou	600	600
Red Rock Valley	Siskiyou	11,000	0
Grass Lake	Siskiyou	4,400	0
Sisson Valley	Siskiyou	2,200	1,400
Burney and Goose valleys	Shasta	6,000	5,000
Cayton Valley	Shasta	1,700	1,300
Hat Creek	Shasta	4,500	3,000
Hay Fork and scattering	Trinity	8,000	6,355
Pit River and tributaries from McCloud River to Burney Creek	Shasta	1,700	1,700
Sacramento River above Pit River	Shasta	500	328
McCloud River, scattering	Shasta	900	900
Scattering		3,000	2,967
Totals		435,000	103,850

The most northerly agricultural areas in this division are those around Lower Klamath Lake, in Butte Valley, and along Klamath River and its small tributaries down as far as Salmon River.

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LOWER KLAMATH LAKE DISTRICT.

This lies at a mean elevation of 4,200 feet along the Klamath Falls branch of the Southern Pacific Railroad near Dorris. Exclusive of uncropped marshes immediately bordering or forming part of Lower Klamath Lake, the agricultural area approximates 23,000 acres, of which 4,600 acres, chiefly in meadow, are reported irrigated, this acreage not including sub-irrigated marsh lands. The land in the district is mostly held in a few large stock ranches, with several small ranches along Sleepy Creek and on the better drained marsh lands. The normal annual precipitation is estimated as 15 inches. The principal water sources for irrigation are Willow and Cottonwood creeks, the former carrying 9.6 cubic feet per second at low stage in 1909, and gagings on the latter in the same year varying from 15.3 to 20.1 cubic feet per second.[1] Underground supplies are probably available along Lower Klamath Lake if pumping them becomes justified. Present irrigation is entirely by means of private ditches, use being wasteful. Twenty-seven thousand acres of Lower Klamath Lake marsh lands was originally included in the Klamath project of the United States Reclamation Service and for several years experiments have been conducted to determine the agricultural value of these lands. A preliminary report of these experiments[2] shows these lands to lack essential elements of fertility, to contain a sufficient quantity of black alkali, which can not be leached out by known methods, to render them unfit for crop production, and to possess such conditions of air drainage that low temperatures and killing frosts are likely to occur every month of the year.

BUTTE VALLEY.

With 65,000 acres of agricultural land and 2,800 acres of it reported irrigated, Butte Valley lies northeast from Shasta Valley on the Klamath Falls branch of the Southern Pacific Railroad, at an elevation of 4,200 feet. Only a relatively small portion of the valley is under cultivation. The soil is sandy in the southern and eastern parts and heavier in the vicinity of Butte Lake and in the valley floor north of Macdoel. Until recent years the valley has been used entirely for stock purposes, but subdivision into smaller holdings has been undertaken but not yet with marked result. The tributary watershed of 530 square miles is a combination of lava and desert hills and much of it is relatively flat, near the valley being sparsely covered with juniper and other scrub growth, with pine and fir timber on the higher of the mountains and in the valley at the southern end. The present chief water sources for irrigation are Praether and Butte creeks, both of which are small and sink before reaching the lake. While much of the soil of the valley is well adapted to agricultural growth, liability to summer frosts limits the crops that can be grown and the possible range of production is not yet worked out, although

[1] U. S. Geol. Survey Water Supply Paper No. 271.
[2] U. S. Dept. Agr., Bureau Plant Industry Circ. 88.

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it is certain to be made up of the hardier strains of grains and forage and of such other crops as will stand low temperatures during the growing season. Some slight increase in the irrigated area will come from the better use of the small streams entering from the south, but if any extensive area is irrigated it would appear that the water supply must come from underground sources, which are as yet not understood. The ground water through the valley generally stands from 4 to 10 feet below the surface, but wherever water has been found underground sufficient for purposes of irrigation it has come from wells that tap the gravel strata between strata of blue clay of varying thickness and lying at depths of 100 feet, more or less. Attempts to obtain artesian supply have not thus far been successful. A considerable area in the trough of the valley is covered by an alkaline marsh, known as Butte Lake, and land immediately adjacent thereto is of little agricultural value.

KLAMATH RIVER AREAS.

West of the Klamath Lake district and also mostly immediately south of the Oregon line lie the scattered areas along Klamath River and smaller tributaries, the largest and most accessible and therefore the most important being near the Southern Pacific Railroad in the general neighborhood of Hornbrook. The elevation of these areas from the mouth of Salmon River, in southeastern Siskiyou County, to the Oregon line varies from 1,800 to 3,000 feet. Above the mouth of Shasta River the aggregate of the areas approximates 20,000 acres, of which 5,500 acres are irrigated, distributed as follows: Klamath River, 2,800 acres; Little Bogus Creek, 100 acres; Big Bogus Creek, 1,100 acres; Camp Creek, 60 acres. There is always likely to be water enough in Klamath River for pumping to the small areas, but pumping is not feasible in all cases. For the tributary creeks no gagings are available, but assuming the rate of run-off per square mile as on Klamath River above Keno, for which gagings are available,[1] sufficient, or more than sufficient, water is available, with storage, to irrigate all available land except on Little Bogus Creek. At present, one small coöperative ditch irrigates about 500 acres near Hornbrook; land along the tributary creeks is irrigated by small private ditches, and along Klamath River mainly by current wheels. The present low-water flow of the creeks is mostly utilized and further irrigation development on them must come through storage, by pumping from underflow, if found feasible, or from Klamath River, or by gravity diversion from the upper Klamath to lands along Bogus and Willow creeks. Below the mouth of Shasta River the aggregate agricultural area is only 3,100 acres, lying in pockets of 10 to 300 acres along Klamath River and Humbug, Parkhouse, Daggett, Beaver, Seiad, Indian, Camp, Horse, and McKinny creeks, with all of it irrigated. Owing to the lack of additional valley land here and the remoteness

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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of the areas from lines of travel, little if any additional development under irrigation can be looked for below the Shasta.

At present the most important valleys in this division are Shasta Valley, Scott Valley, and Fall River Valley.

SHASTA VALLEY.

Including the local valleys about Yreka and Little Shasta, Shasta Valley comprises an area of 158,000 acres of agricultural land lying along the San Francisco-Portland branch of the Southern Pacific Railroad a few miles south of the Oregon line. The mean elevation of the valley is approximately 2,650 feet and the principal towns are Yreka, Montague, Little Shasta, Gazelle, and Edgewood. The valley floor is considerably broken by buttes, one line cutting off Yreka on the west, another cutting off Little Shasta Valley on the east, and an indefinite number lying scattered south of Little Shasta. Southeast of Little Shasta junipers and lava cover approximately 80 square miles of the valley floor and of this less than one half is roughly estimated as cultivable. A further break occurs east of Gazelle, where a considerable area is swamp. Otherwise than as above, however the valley floor is comparatively flat and of good agricultural value and all growing cultivated or native crops. The present irrigation water supply of the valley comes from numerous sources which unite to form Shasta and Little Shasta rivers. The most important of these sources are living springs of almost constant flow, the largest of which, known as Big Spring, discharging a minimum approximating 125 cubic feet per second, with all of them together discharging approximately 150 cubic feet per second. The main Shasta heads in three branches in the Eddy Mountains near Edgewood, and is joined in the upper portion of the valley by Boles, Beaugham, Jackson, Carrick, Willow, Julian, and Yuba creeks, none of these supplying large summer flow, and nearly all of what they do supply being diverted for irrigation prior to reaching Shasta River. Big Spring enters Shasta River below these tributaries, and furnishes practically the entire flow during the late summer. Little Spring, 2 miles west, discharging 8 to 9 cubic feet per second, would also enter Shasta River in the same vicinity were it not all diverted into three ditches for irrigation. Little Shasta River, which, with the springs feeding or adjacent to it, furnishes the main additional water supply of the valley, enters the main Shasta a short distance south of Montague. The springs of Little Shasta Valley are more numerous than along the main Shasta, the largest being Cleland Spring, with a constant flow of about 13 cubic feet per second. Others are Bassey Branch and Martin Springs, each with approximate discharge of 3.5 cubic feet per second. Isolated gagings only are available for Shasta River, the largest measured flow having been made four miles northeast of Yreka on June 26, 1907, when an hydrographer of the United States Geological Survey found 250 cubic feet per second.[1] Gagings made by

[1] U. S. Geol. Survey, Water Supply Paper No. 251.

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the Irrigation investigations in 1911 for the Geological Survey one mile south of Montague showed 101.91 cubic feet per second, at probable low water, on August 24, and 157.35 cubic feet per second, on October 25. No gagings for Little Shasta River are available other than one made by the Irrigation Investigations August 21, 1911, when the flow was 7.24 cubic feet per second 1.5 miles northeast of Little Shasta post office, this being considered by local residents as slightly above the minimum flow. Of the flow of the other tributaries of Shasta River nothing is known other than that it is wholly used in irrigation during the low-water months and that considerable volumes of water are carried at other seasons. No reservoir sites tributary to Shasta Valley are known to have been surveyed. Power development near the mouth of Shasta River controls part of the flow, but conservative estimates of possible run-off from the tributary drainage indicate that, if stored, water is at hand for the irrigation of a considerably larger area than now receives water. Underground water is available in some parts of the valley, particularly in the vicinity of Big Spring, where some pumping development already exists, and probably also along the bed of Shasta River. In both Shasta and Little Shasta valleys, considerable areas are in urgent need of drainage. The water supply most generally counted on for increasing the irrigated areas in Shasta and Little Shasta valleys is Klamath River, to be diverted above Shovel Creek in general accordance with reconnaissance surveys of the Reclamation Service in 1904–5. By these surveys 65,600 acres was found to be irrigable from Klamath River and 5,000 acres irrigable from Little Shasta River and adjacent springs.[1]

Owing to the fact that land holdings in Shasta Valley are large, future irrigation development will largely depend on comparatively few interests. At present irrigation is mainly confined to meadows and alfalfa. With the exception of one small coöperative ditch in Little Shasta Valley, watering 1,550 acres, and Yreka ditch near Gazelle and Edgewood, which although privately owned waters a number of farms in satisfaction of old rights, irrigation in Shasta Valley is accomplished by a large number of small private ditches.

Owing to uncertainty as to possibilities of storage tributary to Shasta Valley or as to the final feasibility of bringing water from the Klamath, it is difficult to estimate the ultimate irrigation possibilities of the area. There seems little doubt, however, that the present irrigated area can eventually be nearly trebled, the underground sources and possible stoppage of present waste together probably being sufficient for doubling the acreage now watered.

[1] U. S. Reclamation Service, Fourth Annual Report.

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SCOTT VALLEY.

Next to Shasta Valley, this is the most important agricultural section in Siskiyou County. It lies between mountains 4,000 to 8,000 feet high, with a mean elevation approximately the same as that of Shasta Valley, and a total area of 55,500 acres. The agricultural land consists principally of bottom land adjacent to Scott River and bottom land lying in narrow strips along the streams tributary to it. Excluding swamps, all of the valley floor is irrigable, with 16,300 acres now irrigated. The latter area is largely watered by the creeks entering the valley from the south and west, rather than by the main Scott River.

Although 20 miles from the nearest railroad, Scott Valley has reached a considerable development. While tributary mines, especially along Salmon River, are of industrial importance to the valley, it is itself devoted mainly to dairying and stock raising, with grain growing on the higher dry lands. Because of its isolated position the valley is very largely self-sustaining agriculturally and therefore generally prosperous. Irrigation enterprise consists in one coöperative system—Farmers Ditch Company—and numerous private ditches. In addition, one or two pumping plants have recently been installed to water some of the land on the east side of the valley, with others contemplated. The ditches from the west-side creeks are mostly short and cover land riparian to and on both sides of the creeks at their entrance to the valley. Including 2,700 acres of swamp land in the trough of the valley, there are some 8,500 acres that need drainage and to cover which a levee and drainage district has been proposed, but not yet organized. Land holdings in the valley average over 250 acres, with many over 400 acres. The use of irrigation water is as a rule extravagant. Under Farmers Ditch the assumed duty is 1.5 inches per acre, or about 1 cubic foot per second to 33 acres. As in other stock-raising and dairying sections of northern California, the crops grown are meadow hay, alfalfa, and grain, the latter very largely oats. At one time a number of orchards were planted in the valley. Now, however, practically no fruit is grown commercially.

The water supply of Scott Valley is limited chiefly to Scott River and the tributaries entering from the south and west, the upper watersheds of which are high and snow-covered in winter. Very little water comes from the east-side range. Of the 711 square miles of drainage tributary to the valley, 243 square miles forms the area above and including that of Clark Creek. No measured rainfall or stream data are available, but the rainfall is sufficient and the drainage of such a character to indicate clearly that there is ample water at hand in the course of the year's flow to irrigate the entire valley if it could be conserved. At present the low-water flow is all utilized.

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FALL RIVER VALLEY.

Although the most isolated of the larger northcentral mountain valleys, this is one of the most important of the agricultural areas in this division and second only to Shasta Valley. It is located along Pit and Fall rivers at an elevation of 3,400 feet in northeastern Shasta County, with approximately 10,000 acres along Pit River in western Lassen County that is properly classed with it. Being 85 miles distant by wagon road from Redding and 20 miles from the nearest railroad, at Bartle, the valley lies so far away from usual paths of travel that its exceptional irrigation resources are far less developed than customary even in the northern mountain areas. The area of the valley is taken as 66,000 acres, of which 24,700 acres is reported irrigated. Of the latter, about 17,500 acres are in one holding, whose irrigation has been accomplished by reclamation of Tule Lake and the utilization of water drained from the adjacent swamp, with the remainder chiefly immediately along Pit River about Pittville, McArthur, and Fall River Mills. The irrigated crops are clover, timothy, and alfalfa. Much of the valley, however, is devoted to dry grain farming, but this having been practiced for many years and the normal rainfall approximating only about 20 inches, it is not now generally profitable. The local water supply is relatively the largest during the irrigation season of any important area in northern California, Fall River originating in the valley in two springs whose measured discharge at Fall River Mills was found to be 1,510 cubic feet per second in September, 1903, when supposedly constant.[1] In addition, Pit River passes through the southern portion of the valley and with storage above, if that were necessary, could be made to furnish an irrigation supply here, and Beaver Creek, with a small supply, enters the Pit near Pittville. There can be no question therefore of the availability of a water supply for the entire valley and that it can all be classed as irrigable. Power development will eventually complicate the use of water for irrigation, but although this is projected and filings have been made for it on Fall River, utilization has not yet been effected. Further irrigation development will be by pumping as well as by gravity, Fall River being so situated with reference to the adjacent irrigable lands as to make pumping both economical and desirable and to assure its employment on a considerable scale when hydroelectric power is at hand.

SALMON RIVER AND TRIBUTARIES.

An area of 574 acres of irrigated land, which probably includes all of the agricultural land, is reported along Salmon River and its forks and Black Bear, Taylor, and Crawford creeks, in Siskiyou County. This land is similar to that along the main Klamath. The Salmon River section being a mining district, like the lower Klamath section, the small areas that can be farmed are, because of their

[1] U. S. Geol. Survey, Water Supply and Irrigation Paper No. 134.

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scarcity, of considerable local value, but still of little general importance. Communication with this district from the east is usually by way of Etna Mills.

RED ROCK VALLEY.

This is a flat to rolling valley 4,400 feet high lying 12 miles east of Butte Valley and covering an area of about 11,000 acres. The precipitation here is probably about the same as that in Butte Valley. Although the soil seems well suited for agriculture, information at hand discloses no water available for its irrigation. No streams enter the valley, and the only known possible source of water will be wells, of which none have been found sunk for irrigation purposes.

GRASS LAKE.

This valley is 10 miles east of Shasta Valley and comprises a swamp area of 4,400 acres lying at an elevation of 5,100 feet. It is entirely devoted to wild native grass and no land is irrigated. The only water supply available is from springs and underground sources. The valley is of no agricultural consequence without drainage. By draining this area, water could probably be developed for lower lands, of which there are about 520 acres in the neighborhood of Sheep Rock, now farmed dry.

SISSON VALLEY.

This is a small mountain valley situated about Sisson, directly under Mt. Shasta at an elevation of 3,400 feet, of which 2,200 acres are cleared, with an indefinite additional area that may later be cleared and irrigated. The chief crops grown are meadow hay, vegetables, and hardy fruits, the meadow hay the main irrigated crop, the irrigated acreage of which is 1,400 acres. The normal annual precipitation here being nearly 40 inches, little irrigation is needed for cultivated crops. Springs and artesian flow are of frequent occurrence, Big Spring, at the north end of the valley, furnishing the main supply to the numerous small ditches present. At present most of the good land is under cultivation. Local capital is concerned in a proposed project for clearing more of the land now wooded and irrigating it from the upper Sacramento.

BURNEY AND GOOSE VALLEYS.

These lie tributary to Pit River southwest of Fall River Valley. Of an aggregate of 6,000 acres of land in them, 5,000 acres in timothy, clover, and alfalfa are irrigated. With more economical use the tributary drainage of 136 square miles would supply sufficient run-off for irrigating all of the land. The used water supply comes from Goose and Burney creeks. The water sinks about 4 miles below Burney Creek and does not rise again until it has passed below the agricultural land. Goose Valley was formerly a swamp and known as Goose Lake,

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but it has been reclaimed both by intercepting the inflow and by drainage. Except in the Goose Lake area, irrigation methods are reported crude.

CAYTON VALLEY.

This small area of 1,700 acres, of which 1,300 acres are irrigated, lies west of Fall River Valley, along Cayton and Clark creeks, at an elevation of 3,600 feet. The drainage area consists of 15 square miles of steep lava hills and the two small creeks should furnish enough additional water for the small unirrigated area.

HAT CREEK AREA.

This consists of approximately 4,500 acres of valley land scattered in pockets for 25 miles along Hat Creek, a tributary of the Pit 10 miles below Fall River. The elevation of the agricultural lands varies from 3,000 to 4,000 feet and the irrigated area is reported as 3,000 acres. The tributary drainage area is 425 square miles and the run-off from this is sufficient to irrigate all of the agricultural land present, although no discharge gagings are available to indicate the character of the stream flow. When the section was visited litigation was under way that sought to establish the right of a power company to divert Hat Creek into Cow Creek for power purposes. Owing to the small size of the scattered areas here, but little irrigation increase is to be expected.

SACRAMENTO RIVER NORTH OF PIT RIVER.

Physical conditions along Sacramento River north of the Pit make irrigation of little importance. The irrigation census of 1909 reported only 328 acres irrigated here, and the absence of much additional agricultural land will prevent any increase of consequence. The land now watered is in pockets of 5 to 20 acres each lying along the creeks in the hills.

TRINITY COUNTY AREAS.

Trinity County is almost wholly mountainous, with only 8,000 acres the approximate aggregate area of valley agricultural land. The largest agricultural areas are on Hay Fork of Trinity River, the others being scattered along the main Trinity and East and Stewart's forks, and Weaver Creek. The irrigated holdings are all small and irrigation practice is more or less primitive, consisting mainly of the flooding of small mountain meadows and gardens. Of 178 irrigators reported in the irrigation census of 1909, only 10 watered holdings of over 100 acres. The total irrigated area reported in the county was 6,355 acres, and as the total area of agricultural land is but little in excess of that, but little increase is possible. There is much land in the county at present timbered that may some time become agricultural and therefore irrigated, but this is not considered likely for some years. It is significant that in the irrigation census of 1909 the irrigators reported the present irrigated area as constituting in the aggregate 67 per cent of the area they ultimately expected to water.

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PIT RIVER BETWEEN BURNEY CREEK AND McCLOUD RIVER.

Approximately 1,700 acres of irrigated land was found scattered in small pockets of meadows and gardens along Pit River and Rock, Nelson, Kosk, Hatchet, Montgomery, and Squaw creeks. While an additional area may ultimately be irrigated it will first need clearing and this is not likely to be undertaken at present. For the land now watered, the supply is sufficient except for summer scarcity on some of the creeks.

SUMMARY.

Recapitulating the data given above as to the irrigation resources of the northcentral mountain valleys, it is found that approximately 435,000 acres are valley agricultural land with approximately 104,000 acres of this now irrigated. Lack of stream gagings prevents a satisfactory estimate of the total quantity of water available for irrigation but this can be approximated for the purposes of this report on the basis of the acreage now irrigated and that which it is estimated can be irrigated in the future. If present wasteful use were to continue, there would be little opportunity outside of Fall River Valley and along the Klamath for increasing the irrigated area from supplies now immediately at hand. But as irrigators better understand the injury resulting from too much water, as they substitute for meadows alfalfa and other crops normally requiring less water than meadows, and as some way is worked out by the State that will facilitate the use of the water that is not now used at all, the present irrigated area should be nearly doubled without much storage or without carrying supplies from relatively distant sources, as from Klamath River to Shasta Valley. Assuming a duty of 1.5 acre-feet per acre per year, and also that some storage and some long-distance conveyance will be found feasible and be carried out, it is believed that the present irrigated area will eventually be increased to from 225,000 to 250,000 acres, or to more than one half of the total area of valley agricultural land found. Using the larger of the two limits and the annual duty of 1.5 acre-feet per acre assumed as eventually practicable would require 375,000 acre-feet of water annually. After analyzing the data that have been collected, there can be little doubt that such a quantity is economically available to the valley agricultural lands of this irrigation division of California.

NORTHEASTERN PLATEAUS AND VALLEYS.

The larger part of this division or irrigation zone lies in the Great Basin drainage and is all within Modoc and Lassen counties. It mostly ranges in elevation from 4,000 to 5,000 feet, with normal average rainfall on the agricultural areas usually ranging between 14 and 22 inches. Chiefly lying east of the main crest of the Sierra Nevadas, its agricultural characteristics more resemble those of northwestern Nevada than those of interior California. Although such hardy fruits

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as apples are successfully grown in the more favored valleys where marketing conditions warrant, the climatic conditions of a high intermountain country make the agriculture essentially characteristic of the live stock industry. Irrigation is, therefore, largely that of the meadow or the alfalfa field.

Of a total land surface of 5,662,080 acres, the tabular summary shows 867,000 acres of plateau or valley agricultural land topographically irrigable, with 161,930 acres irrigated. Portions of Modoc and Lassen counties have long been prosperous agricultural communities, but recent transportation improvements have started a considerable increased development.

SUMMARY OF VALLEY AGRICULTURAL AND IRRIGATED AREAS.

The following table gives the valley agricultural and irrigated areas in the northeastern divisions of the State:

Summary of valley agricultural and irrigated areas in northeastern lava plateau region, comprising Modoc and Lassen counties.

Area.	County or counties.	Agricultural land. Acres.	Areas irrigated. Acres.
Surprise Valley	Modoc	113,000	35,200
Goose Lake Valley	Modoc	39,000	5,800
Fandango Creek	Modoc	1,300	200
North Fork Pit River	Modoc	2,300	2,300
Alturas and South Fork Pit River	Modoc	40,000	18,600
Rattlesnake Creek	Modoc	8,000	0
Lost River drainage	Modoc	47,000	2,900
Fairchild Meadow and Antelope Plains	Modoc	25,000	1,300
Ingalls Valley	Modoc	700	0
Warm Spring Valley	Modoc	32,000	2,050
Black Canyon	Modoc	1,200	500
Stone Coal Valley	Modoc	1,000	500
Round Valley	Modoc	6,000	1,200
Big Valley	Modoc and Lassen	83,000	14,500
Ash Creek Valley	Lassen	6,500	4,000
West Valley	Modoc and Lassen	1,200	1,200
Jess Valley	Modoc	4,500	3,400
Little Valley	Modoc and Lassen	900	900
Dixie Valley	Modoc and Lassen	2,900	1,200
Madeline Plains	Lassen	153,000	3,900
Dry Valley	Lassen	3,000	0
Grasshopper Valley	Lassen	6,300	1,900
Painters Flat	Lassen	2,000	0
Snake and Rush creeks	Lassen	4,700	600
Secret Valley	Lassen	19,000	1,280
Bull Creek	Lassen	2,700	0
Horse Lake	Lassen	5,400	2,600
Eagle Lake	Lassen	1,700	200
Willow Creek	Lassen	13,900	7,100
Susan River	Lassen	66,000	22,300
Honey Lake Valley	Lassen	154,000	12,200
Long Valley	Lassen	9,300	4,100
Scattering, unlocated	----------	10,500	10,000
Totals	----------	867,000	161,930

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Beginning with the north, the largest or agriculturally most important areas are Surprise Valley, Goose Lake Valley, Alturas, Warm Springs Valley, Big Valley, Madeline Plains, and Honey Lake Valley.

SURPRISE VALLEY.

Surprise Valley, lying in the extreme northeastern corner of California at an elevation of 4,800 feet, although 25 miles from railroad transportation, is a well settled community under relatively high irrigation development. While irrigation is thus far entirely by small private ditches, with spring use more or less wasteful, the necessity for water, its general scarcity, and its consequent high crop-producing value, have compelled better use than in most other parts of the division. About 60 per cent. of the grain raised is irrigated, as is the alfalfa not cut for seed, and the family orchards and gardens, only the two latter receiving much water in the summer. The irrigation water supply of Surprise Valley is limited to a number of short, small streams flowing from the steep eastern slopes of Warner Mountains, some artesian flow in the valley floor and such run-off as can be collected into Cowhead Lake Reservoir from 170 square miles of mostly untimbered, sagebrush watershed in California and Nevada.[1] Aside from fuller spring use of the small creeks from Warner Mountains, such individual local storage from them as is found feasible, and the possible increased use of artesian flow, the proposed development of Cowhead Lake for irrigating lands on the east side of the valley furnishes the only opportunity for watering the 77,800 acres in the valley still unirrigated.

GOOSE LAKE VALLEY.

Goose Lake Valley, with a mean elevation of 4,900 feet, lies partly in Oregon but contains 39,000 acres of fine valley agricultural land in California, with 5,800 acres now irrigated. This land immediately joins Goose Lake and because of its topography and proximity to the lake is favorably located agriculturally. Present irrigation is by small private ditches from seven small creeks flowing from Warner Mountains, and having estimated low-flow discharges of 2 to 3 cubic feet per second each. With better use of the supply from these creeks and storage where feasible, as it might be made on Fandango Creek, where a known site would furnish water for at least 2,000 acres, considerably more land in this valley might be irrigated by gravity than receives water now. A questionable source of supply is Goose Lake by pumping. One analysis of the water of the lake made by Prof. G. E. Colby of the University of California indicates the presence of considerable quantities of injurious alkali.

FANDANGO CREEK AREA.

This small area is along Fandango Creek, a tributary of Goose Lake on its east side. The elevation of the area is 5,100 feet and the drain-

[1] The normal rainfall at Fort Bidwell is 20.13 inches.

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age area 17 square miles. At present 200 acres are in hay crops irrigated. It would seem as if the chief worth of the area would be for storage as its agricultural value is not high.

ALTURAS AREA.

The uplands about Alturas differ from Surprise and Goose Lake valleys in that they form no definite or continuous valley areas, the irrigable and irrigated lands not being confined to bottoms. The economic limits of the irrigable lands are therefore difficult to determine with exactness in the absence of definite high-line surveys or of exact knowledge as to the ultimate assembling of the water supplies. North of Alturas, along North Fork of Pit River, all of the readily available land, amounting to about 2,300 acres, is now irrigated. A small area is also irrigated on Parker Creek, which enters the Pit above Alturas. Both the largest irrigable and the largest irrigated areas tributary to Alturas, however, extend along South Fork of Pit River some 20 miles south of the town, although both northwest and southwest of Auturas are sagebrush benches of considerable size that will eventually be watered. Of 40,000 acres of irrigable land about Alturas, 13,000 acres are in a single holding along South Fork of the Pit, this area having been reclaimed from a swamp condition by two drainage canals 30 and 12 miles long, respectively, the former also serving to supply irrigation water when and where needed. Including the flooded meadows, 18,600 acres were reported irrigated about Alturas in 1911.

RATTLESNAKE CREEK AREA.

This is an undeveloped area of roughly 8,000 acres lying at an elevation of 5,000 feet 8 miles north of Alturas. A flat tributary drainage area of about 50 square miles would supply some water for irrigation here if storage were available, but none is known. The drainage is of low water-yield, however, and the area itself is agriculturally not important. Any water supply that would be yielded would be light and variable.

LOST RIVER DRAINAGE.

Extending north from Pit River to the Oregon line and lying between Tule and Goose lakes is an uneven plateau country that forms Lost River drainage and lies at elevations varying from 4,000 to 5,000 feet high. In all there is roughly estimated to be 47,000 acres of agricultural land. Of this 700 acres of bottom land along Willow Creek, 1,500 acres in Steele swamp, and 700 acres in Boles Meadow, a total of 2,900 acres, are crudely irrigated. The water supplies tributary to the area are mainly Lost River and tributaries, including North Fork, South Fork, and Fletcher, Beaver, Bottle, and Rock creeks. The United States Reclamation Service has built a dam below Clear Lake in connection with their Klamath project which will store the water heretofore draining to Lost River. The original plan of the Reclamation Service was to irrigate 35,000 acres in California along the east side

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of Tule Lake by the use of Clear Lake storage, but owing to excessive cost this portion of the project has been deferred. Their plans also involve the reclamation of 27,000 acres of Tule Lake, by evaporation and stopping of the inflow through Lost River.

FAIRCHILD MEADOW AND ANTELOPE PLAINS.

Another high plateau section, with, roughly, 25,000 acres of agricultural land, lies 15 miles northwest of Alturas, comprising Fairchild Meadows and Antelope Plains. The elevation here is 5,000 feet. Fairchild Meadows is now a swamp and its drainage has been considered in connection with the irrigation of Boles Meadows on the north. The irrigation of Antelope Plains by the storage of torrential flow has also been considered. The drainage area of these two areas combined is of indefinite bounds but of about 150 to 200 square miles. The run-off yield is considered independable and development of consequence is said to be unlikely. Counting wild flooding, 1,300 acres are reported as now irrigated.

INGALLS VALLEY.

This is a small undeveloped area northeast of Alturas of the same character as Fairchild Meadow and of approximately equal high elevation. The only available water supply is also small, torrential, and unreliable. No land is now irrigated.

WARM SPRING VALLEY.

Warm Spring Valley, lying next below Alturas along the Pit, has a total area of approximately 32,000 acres, exclusive of the higher benches into which a portion of the valley merges. The area reported irrigated in 1911 was 2,050 acres, not including naturally flooded meadows. Aside from the use made of Pit River, irrigation water for land in this valley is obtained from Canyon Creek and from several small reservoirs, each of which supplies several hundred acres. No irrigation companies operate here. The total drainage tributary to this valley at its outlet is 1,560 square miles.

ROUND VALLEY.

Southwest from Warm Spring Valley, Round Valley lies on Ash and Rush creeks, both tributary to the Pit. Of 6,000 acres of irrigable valley land, 1,200 acres are now irrigated. The valley has a total drainage above Adin of 260 square miles. Stream-flow records maintained on Ash Creek during parts of 1904 and 1905 by the Geological Survey[1] showed a mean annual run-off of 98,500 acre-feet. A considerably smaller supply, with storage above feasible, of which some could be provided in Ash Creek Valley, would suffice for the complete supplemental irrigation of this valley, were the water available to be utilized at this place instead of, possibly, in Sacramento Valley.

[1]U. S. Geol. Survey, Water Supply Papers 134, 177, 213, 251.

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BIG VALLEY.

Big Valley, selected by the Reclamation Service as the best reservoir site on any of the Sacramento River tributaries, is situated but a few miles below Round Valley, Ash Creek entering the Pit within this area. The total area in the valley is 83,000 acres, of which 14,500 acres, including flooding from sloughs, was irrigated in 1911. The available water sources for irrigating this valley are Pit River, Ash Creek, and Willow Creek. Gagings at Pit River at the proposed dam site at the mouth of the canyon leading from Big Valley, which is below Ash and Willow creeks, showed a mean annual run-off from 1904 to 1908 of 733,000 acre feet.[1] Much of the valley is now swamp and needs drainage before irrigation, but if full agricultural development were attempted, the water supply available from Pit River at Canby and from Ash Creek at Adin give the best basis for estimates. The stream-flow figures for the former for a period 1904 and 1905 show a mean annual flow of 424,000 acre-feet and for the latter for the same period a mean flow of 98,500 acre-feet. With storage in one or more of the upper valleys, such as Round Valley or Warm Spring Valley, which is not likely for use in Big Valley, complete irrigation development of this area would be possible. Less complete development would follow storage in Grasshopper Valley, on Ash Creek, or taken in connection with storage in Jess and West valleys, to the exclusion of use in Warm Spring Valley or around Alturas, the entire area of Big Valley might be watered.

BLACK CANYON.

This is a small area of 1,200 acres adjacent to Warm Spring Valley. The water supply depends on the run-off from the plateau to the north. Part of this is at present stored and used to irrigate 500 acres.

STONE COAL VALLEY.

This area of approximately 1,000 acres, of which 500 acres are now irrigated, is situated 10 miles north of Big Valley. A drainage area of 15 square miles is said locally to furnish more than enough water until about June 1 to irrigate about one half of the valley. If storage is feasible, and with economical use, water is at hand for watering all of the valley.

ASH CREEK VALLEY.

This area of 6,500 acres is on upper Ash Creek 20 miles east of Bieber, at an elevation of 5,100 feet. Several large ranches cover the valley, with 4,000 acres of wild hay reported irrigated. With Ash Creek, Cottonwood Creek, and springs there is water present under more economical use for all the land. A small reservoir on Cottonwood Creek carries some of the flood waters of that stream over to late summer. The watershed tributary to Ash Creek Valley approximates 110 square miles.

[1] U. S. Geol. Survey, Water Supply Papers 134, 177, 213, 251.

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WEST VALLEY.

This area lies in a narrow strip along West Valley Creek, a tributary of South Fork of Pit River, 20 miles south of Alturas, at an elevation of 4,900 feet. The entire valley is in one ownership and all irrigated, the total area being 1,200 acres. This valley has been surveyed by the Reclamation Service[1] as a possible reservoir site, a 70-foot dam being estimated as capable of holding back 94,579 acre-feet. The average run-off at this site is not, however, sufficient to fill a reservoir as large as could be made here. The tributary watershed is 150 square miles.

JESS VALLEY.

This is also along a tributary of South Fork of Pit River, its area being 4,500 acres, of which 3,400 acres in alfalfa, wild hay, and grains is reported irrigated. The elevation of the agricultural land here is from 5,100 to 5,300 feet. Mill, East, and Harvey creeks, all perennial, furnish the water supply of the valley, these draining 91 square miles of elevated watershed and carrying an estimated combined minimum flow of 12 to 15 cubic feet per second. Surveys made by the Reclamation Service[1] show that a 60-foot dam in Jess Valley would give an impounding capacity of 224,560 acre-feet.

SUMMARY OF CONDITIONS ALONG UPPER PIT RIVER.

There are two main lines on which further irrigation development about Alturas and along Pit River both above and below Alturas might take place, and the future is likely to see results accomplished in some measure through a combination of these. The first involves a comprehensive scheme for the fullest possible utilization of all water sources available and the irrigation of the lands below them according to an orderly plan; the second involves the less economical but probably the more practicable development by the individual, community, or corporation, with each project wholly independent of any other. Whatever form development takes, it is bound to be intimately connected with irrigation in Sacramento Valley, because the Pit forms one of the important tributaries of the Sacramento.

Counting all agricultural areas along Pit River and main tributaries as far down as Big Valley, but omitting West and Jess valleys, because of their suitability for reservoirs, there are 163,300 acres. Assuming the possible ultimate use of Big and Round valleys as reservoirs for Sacramento Valley, 77,300 acres remain, of which 22,950 acres were reported watered in 1911, leaving about 54,000 acres still to be irrigated. This relatively small area should undoubtedly be brought under development. For this, water could be made available from three main sources aside from the direct flow of Pit River, viz., Goose Lake,

[1] U. S. Reclamation Service, 5th Annual Report.

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storage in West and Jess valleys, and smaller individual storage to which the topography of the country is well suited. In addition, pumping from underflow of the streams could be made to yield for lands not readily reached by gravity.

Because of the possible ultimate use of Big and Round valleys, as well as of Ash Creek Valley, as reservoirs in connection with Sacramento Valley irrigation, any consideration of the use in Modoc County of the waters of the upper Pit must carry the reservation of possible alternative use lower down. Generally speaking, the drainage of the upper Pit is composed of relatively flat and sparsely timbered volcanic hills. Quite careful water-supply investigations covering this drainage have been made by the Geological Survey and Reclamation Service in connection with the Sacramento Valley irrigation project at one time proposed by the Reclamation Service.[1] In these studies, the use of Goose Lake water has been an important feature. This lake has a surface area of 186 square miles and a tributary watershed of 1,250 square miles. By diverting into Pit River sufficient water of Goose Lake to reduce its surface area to 83 square miles, it was estimated that the evaporation of 260,000 acre-feet per annum could be prevented, and this supply partly used along the upper Pit but mostly stored in Big Valley Reservoir, where a smaller exposed surface would reduce the evaporation losses. Reasoning from an assumed annual rainfall on the lake of 15 inches and from an assumed annual evaporation from the lake surface of 47 inches, the mean annual run-off from Goose Lake watershed figures approximately 300 acre-feet per square mile, or at least enough for the irrigation of 100 acres per square mile of drainage. A diversion channel from Goose Lake into North Fork of Pit River would be necessary to make this water supply available, because Goose Lake does not now overflow into the Pit.

Aside from Goose Lake, West Valley and Jess Valley reservoir sites furnish the principal means of storage for the upper Pit areas. With dams at these sites 70 feet and 60 feet high, respectively, the Reclamation Service has figured a storage capacity of 224,560 acre-feet at the former site and of 94,579 acre-feet of the latter.[2] The drainage areas tributary to these sites are not large enough, however, to fill the reservoirs. Two years' run-off from Jess Valley gave an average annual yield for 1904 and 1905 of 55,000 acre-feet, but as 1904 was a year of more than average rainfall, an average annual yield of 45,000 acre-feet gives a safer basis for estimate. Measured run-off from West Valley for the same period suggests a safe average yield of 20,000 acre-feet per year from this source. This total possible storage above the agricultural lands along the upper Pit of 65,000 acre-feet should, if fully and conservatively utilized, and supplemented by smaller

[1] U. S. Reclamation Service, 5th Annual Report: address of J. B. Lippincott, supervising engineer, before Congressional Irrigation Committees at Red Bluff, June 15, 1905.

[2] U. S. Reclamation Service, 5th Annual Report.

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individual storage, amply supply irrigation to the entire available area during periods of deficient direct flow.

LITTLE AND DIXIE VALLEYS.

These are two small areas on tributaries of Pit River below Big Valley. The former, on Horse Creek, has an elevation of 4,200 feet, and an area of 900 acres, all irrigated. Dixie Valley, also on Horse Creek, has an elevation of 4,300 feet and an area of 2,900 acres, nearly all of which is held in Indian allotments, with 1,200 acres irrigated. Important development is not likely in either of these small areas, although the tributary watershed should supply all of the water needed for full irrigation development.

MADELINE PLAINS.

Madeline Plains, which form the next large agricultural area south of Alturas, lie at an elevation of 5,400 feet, and embrace a total of 153,000 acres, of which 3,900 acres were irrigated in 1911. Being a high plateau and until recently without railway transportation, this area has not reached a very extensive development. Several stock ranches have included irrigated areas, but until recently no attempt has been made to obtain a water supply for the general irrigation of the plains. For several years, however, a land and irrigation company has been prosecuting plans for the irrigation of 40,000 acres in the northern portion of the area, largely completing their canal system of 1911. The main source of water for this 40,000 acres as now developed is Tule Reservoir, into which Cedar Creek, with a drainage area of about 50 square miles above this reservoir, has been diverted. An additional supply has been contemplated by diversion of water from the upper Pit River drainage. Another small creek on the Van Lone ranch is utilized for irrigating about 1,000 acres there. For the eastern portion of Madeline Plains, the only stream sources are Red Rock, Painter, and Buckhorn creeks. Although these streams are snow-fed they are torrential and require storage for use. No gagings of value are available for any of the streams tributary to Madeline Plains. The four creeks named supply the main drainage, with a combined watershed of 217 square miles. If the normal annual rainfall on this watershed were 15 inches, and 20 per cent of this were collected in reservoirs and made available for irrigation, the total supply would be 54,250 acre-feet per annum, or very much less than enough to irrigate the entire Madeline Plains.[1]

DRY VALLEY.

This area of about 3,000 acres lies southwest of Madeline Plains at an elevation of 5,500 feet. No land is irrigated and the only water that enters the valley is torrential and comes in at the north end and sinks

[1]Records of the Geological Survey for 1904 and 1905, as given in Water Supply Papers 134 and 137, show that West Valley Creek, adjacent to Cedar Creek, had a mean measured run-off of 3 inches in depth over the entire area of watershed. Ash Creek, at Adin, 30 miles west, and with a watershed of 260 square miles, gave a measured run-off of 7 inches in depth.

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before becoming available for use. About 10 square miles of watershed might supply water for approximately 500 acres if storage were feasible, but no such development seems possible.

GRASSHOPPER VALLEY.

This area of 6,300 acres also lies southwest of Madeline Plains, with an elevation about 300 feet lower than Dry Valley. About 1,900 acres in wild hay, timothy hay, and grains are now irrigated from two small spring-fed creeks and several small reservoirs. The south end of the valley is a lake which covers about 3,500 acres at times of high water and about 1,500 acres at times of low water, the 2,000 acres of overflow land being cut for hay when the lake recedes. All of the valley, excepting 600 acres, is held in one ranch. Storage in additional small reservoirs or pumping, if underground water is present, will be necesary for increasing the irrigated area.

PAINTERS FLAT.

This small area of 2,000 acres lies along the California-Nevada line southeast of Madeline Plains. It is now used for grazing and as no water supply seems to be at hand for use in irrigation, the area is of no irrigation importance.

SNAKE CREEK AND RUSH CREEK AREAS.

These two areas, aggregating 4,700 acres, border small streams rising in California and draining into Nevada. All of the valley land along Snake Creek, or about 600 acres, is irrigated from springs. Rush Creek is torrential and but little land along it is cultivated. The drainage tributary to this creek approximates 40 square miles of bare hills of low run-off yield, and little irrigation is likely here.

HONEY LAKE VALLEY.

Including Susan River Valley, Willow Creek Valley, Long Valley, and the areas about Honey Lake and along the minor streams draining into it, Honey Lake Valley constitutes the largest and most readily accessible aricultural area in northeastern California. Probably no area of equal importance in California has been more adversely affected by lack of public regulation of water resources. The total area of the valley is substantially 243,000 acres, of which 45,700 acres, including the naturally overflowed and crudely flooded areas, was found to be irrigated in 1911. While a large area of agricultural land lies northeast of Honey Lake, the great bulk of the valley is southeast of the lake and farthest from any water sources other than such as can be found underground. Irrigation has been practiced in this valley for many years and there are numerous canals and ditches leading from Susan River, Willow Creek, and the other streams entering the valley. Aside from one company system from Susan River and two small coöperative associations that have installed pumping plants on Honey Lake, irrigation is effected wholly by individual or

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small partnership enterprise. The highest irrigation development is along Susan River east of Susanville, although even there use is exceedingly wasteful. Farther down, in the Susan River delta, it is little more than the annual submerging of wild grass meadows, under practices perhaps satisfactory to the irrigators themselves and carried on under authority of numerous court decisions, yet which are criminally uneconomic from the point of view of the full development of the entire valley. The only important storage at present used on Susan River is in connection with the principal irrigation company of the valley, which uses McCoy Flat and Hog Flat reservoirs, tributary to Susan River above Susanville, and Lake Leavitt, an artificial reservoir in the valley below Susanville.

In estimating the water resources available for possible increased irrigation in Honey Lake Valley, first place must be given to Susan River. According to scattering records at Susanville kept by the Geological Survey from 1901 to 1905[1] the estimated mean annual run-off of this stream is substantially 102,000 acre-feet. Based on private unpublished reports of several engineers and data gathered by this office, Willow Creek, Petes Creek, Horse Lake, Secret Valley drainage, Long Valley Creek, and the smaller streams of Honey Lake Valley proper, probably yield in mean years 111,000 acre-feet additional, making a total mean run-off for the valley of 213,000 acre-feet. Additional yields have been estimated by some from Eagle, Caribou, Silver, and Feather lakes, but these are not included in the above total. Estimates of the total water-crop have from time to time been made on the basis of evaporation from Honey Lake at an assumed rate of 3.5 feet per annum over a surface of 60,000 acres, giving a total of 210,000 acre-feet. Whatever the actual run-off of the valley, it can not all be stored or used economically in direct flow. Full storage is not probable on Long Valley Creek or on the small streams entering the main valley. Assuming that a part of the flow of Susan River can be diverted into and stored in Eagle Lake, which is the largest natural reservoir site in the valley,[2] and counting that what cannot be held in the upper reservoirs can be stored in Lake Leavitt, full storage should be feasible on this stream. Round Valley, or Willow Creek, and Horse Lake, on Petes Creek, have been figured to store most of the flow of these two streams not used in direct irrigation. Some of the run-off from Secret Valley and Ball Canyon Creek can also undoubtedly be stored. Analyzing these various probable storages in connection with the figures of estimated run-off already given, and figuring on a mixed duty of 1.5 acre-feet per acre under direct use and 2 acre-feet per acre under storage, the probable practical irrigation develop-

[1] U. S. Geol. Survey Water Supply Papers 134 and 177.

[2] Many have believed that Eagle Lake could be made to water all of Honey Lake Valley and a tunnel was partly completed to tap it. Evaporation, however, has generally taken care of the entire run-off into it, except that 5,000 to 7,500 acre-feet are found to seep annually from the lake to feed springs at the head of Willow Creek. During recent years the surface of Eagle Lake has raised slightly. The best that the more conservative estimates have allowed for the lake is to furnish a supplemental supply in years of unusual drought.

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ment in this valley from surface sources is not over 117,500 acres, of which, including Secret Valley, 47,000 acres were receiving water in 1911. The possibilities of irrigation by pumping in this valley are problematical. As already stated, two pumping plants are taking water direct from Honey Lake for irrigation purposes, and a number of irrigation wells have been sunk in the large area southeast of Honey Lake. While there will always be ample water in Honey Lake, its value for irrigation is likely to be small because of the excessive amounts of salts present. Salts in considerable quantities are also carried in some of the well waters, and each well sunk must be tested for quality as well as for quantity before its value can be determined.[1]

SUMMARY.

Recapitulating the irrigation resources of this division of California, the following facts seem clear: There is a total of 866,500 acres of agricultural land reported that is topographically suited for irrigation, with 161,850 acres reported irrigated in 1911, the summer flow of the streams being quite largely diverted and some water stored. Both increased economy in present use, that is in some instances exceedingly wasteful, and additional storage will result in an increased irrigation development, its extent dependent on the water supplies available to the various areas. What these supplies are and something of their character are stated in the tabular summary. Some stream records are available and estimates of the mean annual flow can be approximated in others. For the Great Basin area, including surprise Valley, Madeline Plains, and Honey Lake Basin, 400,000 acre-feet is believed to be a fair figure for the total water crop that might be utilized. For the Pit River drainage down to and including Big Valley, 730,000 is the mean measured run-off. If the area of Goose Lake were reduced as at one time proposed by the Reclamation Service and evaporation of a large quantity of water thereby lessened, and if Lost River drainage waters in California were utilized in California, which is not likely, the total mean available yield in this division outside of the Great Basin drainage might safely be estimated at 1,000,000 acre-feet per annum. If these large water-yields were available over this entire division as land is at hand on which it might be used, a large part of the 866,300 acres of irrigable agricultural land might be watered. Considering conditions of land and water as they are, however, and assuming for this purpose that both Big Valley and Round Valley will be fully developed agriculturally rather than as reservoirs for Sacramento Valley, it is believed that doubling the

[1] In July, 1912, samples of water from Honey Lake and 7 wells southeast of it were analyzed to determine their suitability for irrigation purposes by Prof. Geo. E. Colby, of the California Agricultural Experiment Station. The water from 2 of these wells was reported by Professor Colby as "excellent" for irrigation, that from 3 was reported "suitable," that from 1 "unsuitable," and that from 1 of such quality as "might answer for irrigation on well-drained land." The water analyzed from Honey Lake showed 11.03 pounds of corrosive alkali per 1,000 gallons of water, or enough to deposit 1.8 tons with each acre-foot of water applied. Analysis of water taken from this lake in December, 1909, and May, 1911, showed 5.90 and 7.10 pounds of corrosive alkali, respectively, per 1,000 gallons of water.

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present irrigated area of 161,850 in this division will at least be the maximum development that will be reached. If Big Valley and Round Valley are utilized as reservoirs for Sacramento this total should be decreased by 80,000 acres.

FEATHER RIVER VALLEYS.

West of the crest of the Sierra Nevada in northern California are a number of high mountain valleys of considerable importance both locally and in the aggregate. These lie north of the overland route of the Southern Pacific Railroad and generally along or tributary to the Western Pacific Railway in Plumas and Sierra counties. The elevations of these valleys vary from 3,400 to 5,800 feet. They are therefore all well above the Sierra foothills treated elsewhere and are properly classified as high mountain areas. Irrigation here is almost wholly that of the mountain meadow on which wild hay and a less amount of grain and alfalfa are grown. All of the division is within the upper drainage of Feather River where the heavy annual precipitation of rain and snow gives the streams a volume greatly out of proportion to any needs in this division for irrigation. The normal annual precipitation at stations for which the United States Weather Bureau has records for ten years or more is 42.5 inches at Greenville, 46.3 inches at Quincy, and 89.2 inches at La Porte. Gagings of Feather River at Oroville[1] show an average annual run-off of about 1,600 acre-feet per square mile, or the equivalent of a depth of 30 inches over the entire drainage. Big Meadows, an area of 14,500 acres in this division, is being utilized by the Great Western Power Company for a reservoir, and the lands there consequently have no further agricultural value. In 1909, however, prior to beginning construction on the Big Meadows dam, 1,100 acres were reported irrigated.

SUMMARY OF VALLEY AGRICULTURAL AND IRRIGATED AREAS.

The following summary lists the valley agricultural and irrigated areas in this division of northern California:

Summary of valley agricultural and irrigated areas in the high mountain valleys in Plumas, Sierra, and southwestern Lassen counties.

Area.	County or counties.	Valley agricultural land.	Area irrigated.
		Acres.	Acres.
Sierra Valley	Sierra and Plumas	101,000	23,900
Mountain Meadows	Lassen	13,000	400
Big Meadows	Plumas	----------	1,000
Indian Valley	Plumas	11,000	5,900
Genesee Valley	Plumas	3,100	2,900
Meadow and Spanish Ranch valleys	Plumas	2,250	500
American Valley	Plumas	4,300	4,000
Long and Mohawk valleys	Plumas	1,400	550
Red Clover Valley	Plumas	4,250	2,100
Grizzly Valley	Plumas	8,200	100
Scattering	Plumas	9,500	9,250
Totals		158,000	50,600

[1]U. S. Geol. Survey Water Supply Paper.

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SIERRA VALLEY.

This valley containing 101,000 acres, the largest agricultural area in the division, is at the head of Middle Fork of Feather River, in Sierra and Plumas counties, at a mean elevation of 4,900 feet. The soil of the valley is generally a sandy loam covered in its natural state with a heavy growth of sage and rabbit brush. Some adobe and a little alkali are found in the center of the valley. Continuous rainfall data are not at hand but the fall in 1910 is officially reported for Sierraville in the Weather Bureau records as 17.49 inches. The area reported irrigated in 1911 was 23,900 acres, most of this being north of Sierraville near Loyalton, and on Last Chance Creek. The crops irrigated are the wild hay and alfalfa typical of the division, but the area is generally believed to be suited to sugar beets, although they have thus far been grown only experimentally. With economical use, water is available for the whole of Sierra Valley and eventually, especially if beet culture is successfully introduced, 75 per cent or more of the total acreage may be expected to be receiving water. At present the supply is so abundant north of Sierraville and along Last Chance Creek during flood flow that irrigation is more a matter of distribution than of diversion, low dams and crude ditches carrying the water wild over the meadows. Near Loyalton the water supply is less abundant but one 15-acre reservoir already built indicates the possibilities of small-scale storage. The sources of the water supply now available to Sierra Valley are Last Chance, Smithneck, and Hamlin creeks, underground waters, and springs. While the annual flow in the creeks is large, as indicated by the heavy average run-off of Feather River already mentioned, storage is needed before it can be made available. Sites have been locally surveyed on Last Chance Creek and in the neck of Sierra Valley near Sierraville and ample capacity reported but not officially confirmed. For the Sierraville reservoir water would need to come from Middle Fork of the Feather River. The trough of the valley is naturally moist and underground water is present in considerable quantity, the full extent of which, however, no data are at hand to indicate. Northward from Sierraville quite a body of land is overflowed during floods and the building of drainage works for this has been contemplated but not executed. If present wasteful use can be superseded by more reasonable practice, at least part of the available storage built, some water pumped where the lifts are economical, and possible conflicts with power rights on the Feather avoided or adjusted, the estimated possible increase in the irrigated area of Sierra Valley indicated above is conservative.

MOUNTAIN MEADOWS.

This is an agricultural area of 13,000 acres on North Fork of Feather River in southwestern Lassen County at an elevation of 4,700 feet. Four hundred acres in wild hay and timothy were irrigated in 1911 by means of sloughs and 4 private ditches. The water supply for this valley is a tributary of Rock Creek, which is a tributary of

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North Fork of Feather. The minimum flow of the creek is estimated at 20 cubic feet per second, but the seasonal supply, by greater use in spring, would irrigate a much larger area than the minimum flow furnishes. Storage in the upper one fifth of the valley would give water for nearly the entire lower four fifths, but this has not been seriously contemplated and if undertaken might conflict with power rights in Big Meadows below. Until greater use is made of the summer flow, storage will not assume any importance. Aside from possible conflict in water rights, the entire area can be classed as irrigable.

INDIAN VALLEY.

This is a mountain valley 12 miles north of Quincy on Indian Creek, a tributary of North Fork of Feather, at an elevation of 3,500 feet. At present practically the entire valley is in grain, wild hay, timothy, and alfalfa, 5,900 acres being reported irrigated. The use of the valley as a reservoir site has been considered,[1] the measured annual run-off at Crescent Mills from the tributary watershed of 790 square miles having averaged 600,000 acre-feet from 1906 to 1909, with the normal annual run-off estimated by the Reclamation Service at 500,000 acre-feet. Besides Indian Creek, Cook's Canyon, Lights, and Wolf creeks enter the valley. While the area artificially irrigated is only 5,900 acres, nearly all of the remainder of the valley receives natural irrigation during high water. Much of the valley needs drainage, but it can all be classed as irrigable.

GENESEE VALLEY.

About 10 miles northeast of Quincy there is another small area, known as Genesee Valley, on Indian Creek. The elevation of this valley is approximately 3,800 feet. Of a total of 3,100 acres, 2,900 acres, in two large ranches, are reported irrigated, the irrigated crops being the grain and wild hay typical of the region. The water supply available is of course ample.

MEADOW AND SPANISH RANCH VALLEYS.

Together these form an area of approximately 2,250 acres 9 miles west of Quincy lying at an elevation of 3,800 feet. They are comparatively flat valleys merging into rolling foothills and are watered by Spanish Creek and various small tributaries having a combined drainage area of 45 square miles. One small reservoir has been built at the head of Spanish Ranch Valley. The valleys were formerly heavily timbered and are now only partially cleared, 500 acres in wild hay being reported irrigated. At present crops are chiefly confined to the flat bottoms, but where the higher adjoining areas have been cleared planted, and irrigated, growth is very satisfactory. Water is ample if properly used for irrigating the entire Meadow Valley and Spanish Ranch Valley areas.

[1] U. S. Reclamation Service, 5th Annual Report.

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AMERICAN VALLEY.

This is a flat valley of 4,300 acres in the vicinity of Quincy at an elevation of 3,400 feet. The usual mountain forage and grain crops are grown, 4,000 acres being under private irrigation ditches, with an ample water supply obtained from Thompson, Spring Garden, Taylor, and Spanish creeks. American Valley has been considered as a reservoir site, for which the Reclamation Service found a run-off of 86,055 acre-feet available.[1] It hardly seems likely, however, that this valley will be so utilized.

LONG AND MOHAWK VALLEYS.

These are two narrow areas of 400 and 1,000 acres, respectively, lying along Middle Fork of Feather River in southern Plumas County at elevations of 4,300 to 4,500 feet. A total of 550 acres in scattered pieces is reported irrigated in the two valleys where the agricultural land has been cleared of timber, and there is ample water for the entire areas.

RED CLOVER VALLEY.

This valley lies at an elevation of 5,400 feet along Red Clover Creek, a tributary of Indian Creek, northwest of Sierra Valley. Of a total of 4,250 acres of agricultural land, 2,100 acres are reported irrigated. The run-off from 127 square miles of watershed is ample if it can be controlled.

GRIZZLY VALLEY.

This is a tributary area to Sierra Valley, but being at an elevation of 5,800 feet it is now used for pasture and none of it irrigated. A tributary drainage of 33 square miles furnishes sufficient water for irrigation but the high elevation makes irrigation unlikely. The Reclamation Service reports a reservoir site here with a capacity of 62,000 acre-feet, with 20,000 acre-feet estimated as annually available.[1]

SUMMARY.

Recapitulating the data for the northern Sierra or Feather River valleys, it is found that 158,000 acres are valley agricultural land, with 50,600 acres in wild hay, grains, and alfalfa irrigated. Eliminating Grizzly Valley, because of its high elevation, the valley agricultural area becomes 149,800 acres. The water supply of the areas is in nearly every case ample for irrigating all of the land, but its utilization would involve storage, some pumping in Sierra Valley, and an adjustment or avoidance of conflicts in rights between irrigators and power interests. These valleys being in the main best suited to forage crops, and much of the soil in them being permanently relatively moist, it is not likely that the use of water in irrigation will materially lessen the flow to power and irrigation interests below. Other areas than Big Meadows are sure to be eventually used for reservoir sites for both power and irrigation in Sacramento Valley. If it were not for this fact, an estimate of 65,000 acres as the additional area that will be watered in the future would seem safe.

[1] U. S. Reclamation Service, 5th Annual Report.

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NORTHERN SIERRA FOOTHILLS.

Between the Feather River valleys and the plains of Sacramento Valley is situated the important zone of the Sierra foothills. Through these foothills must pass the many streams that originate in the higher portions of the Sierra and seek their outlet into Sacramento Valley below. The agricultural areas in these foothills are not continuously cultivable, nor are the areas that are cultivable usually valley areas, but rather the more even portions of countless spurs and ridges that are separated by rocky promontories and deep and rugged canyons and gulches. The non-agricultural areas are sometimes so rough as to have little or no value, even for grazing. The natural growth of the foothill belt is mostly brush and non-merchantable timber, the merchantable forests being on the higher slopes of the mountains. The soils are of the reddish types of granitic or volcanic origin and when irrigated are exceedingly fertile. Favorable climatic conditions and water, when available, add to these soils in making the region attractive for fruit growing, and where railroad transportation is easy of access and mining interests are not still paramount, considerable development has been accomplished, especially about Auburn and Newcastle. About 35 per cent of the deciduous fruits shipped from California are taken from the foothill areas of Placer County alone.

As already stated, the water supplies available to the Sierra foothills are the streams crossing them from the higher elevations of the Sierra on the east. In few cases are these streams easy of delivery to the cultivable areas. The larger streams—Feather, Yuba, Bear, American, and Cosumnes rivers—and their forks and main branches flow in deep canyons, making long conduits sometimes necessary to carry their waters to the irrigable lands. Fortunately many of the ditches and pipe-lines of the early-day mining camps, built at costs running into millions of dollars, have been rendered available to more permanent use in irrigation and power, thus making it possible in many cases to water lands whose agricultural products might not alone have yet justified the expense of bringing water to them. But not all of the water that passes through the foothills is available to them, for present and future irrigation development in Sacramento Valley and the hydro-electric power rights that have already become vested or that will become vested in the future, together make it certain that much of the foothill land is destined to remain without irrigation.

The Sierra foothill areas in northern California extend from the vicinity of Whitmore, east of Redding, south through Amador County.

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SUMMARY OF AGRICULTURAL AND IRRIGATED AREAS.

The following tabular summary groups them by counties and according to their location between the principal river systems, giving also the acreages of agricultural and irrigated land.

Summary of agricultural and irrigated areas in northern Sierra foothills.

Area.	County or counties.	Agricultural land. Acres.	Area irrigated. Acres.
North of Feather River:			
Whitmore	Tehama and Butte	24,000	10,262
Paradise Ridge	Butte	12,000	700
Between Feather and Yuba rivers:			
Wyandotte-Bangor	Butte and Yuba	38,000	1,395
Browns Valley	Yuba	25,000	1,750
Between Yuba and Bear Rivers:			
Nevada City-Smartville	Yuba and Nevada	117,000	4,013
Between Bear and American rivers:			
Placer County fruit districts	Placer	104,000	14,000
Orange Vale-Fair Oaks	Sacramento	29,000	4,450
Between American and Cosumnes rivers:			
Georgetown	El Dorado	42,000	1,546
Placerville	El Dorado	26,000	1,613
Folsom-Pleasant Valley	El Dorado and Sacramento	148,000	1,100
South of Cosumnes River:			
Ione-Jackson	Sacramento and Amador	220,000	630
Scattering, unlocated	----------	4,000	3,791
Totals	----------	789,000	45,250

WHITMORE FOOTHILL AREA.

This is a broken area west of Millville, and from Whitmore south to Paynes Creek, lying along or adjacent to the small northeastern tributaries of the Sacramento below the Pit. Counting both the small pockets of creek bottoms and arable foothills, the total area is roughly estimated as 24,000 acres, of which 10,000 acres are along North and South Cow, Oak Run, upper Bear, and Clover creeks, and 2,000 acres are along Paynes, Plum, and Ripley creeks. The agricultural areas are, individually, relatively small and scattered, the surrounding country being hilly and timbered and similar throughout the area. In addition to the creeks named, several smaller streams furnish the available water supply for irrigation. No gagings are at hand for any of these streams, but the area has a total watershed of approximately 250 square miles, reaching elevations of 4,000 to 6,000 feet at the headwaters of the creeks, and an estimated rainfall of 35 to 50 inches. There is, therefore, ample water within the watershed for covering the irrigable lands but storage would be necessary to make it available for greatly increased use. At present 10,262 acres are reported irrigated, 75 per cent of which is between Millville and Whit-

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more. Filings have been made on nearly all of the streams for power purposes and much land on which water has been used for irrigation has been purchased by the Northern California Power Company and the use of the water changed from irrigation to power. In spite of the heavy normal rainfall, the agricultural lands without a water supply for irrigation have a grazing value only. The irrigated crops from Millville to Whitmore are chiefly clover, timothy, grain, alfalfa, and hops. About Manton and Paynes Creek apples and other deciduous crops are important. Where the use of water has been changed to power, numerous areas formerly irrigated have been abandoned. If the ascendency of power interests continues, agricultural values will decrease, except as bottoms continue to produce without water or irrigation supplies are pumped to the most accessible areas from the stream gravels.

PARADISE RIDGE.

This is an area of about 12,000 acres on the ridge between Butte Creek and West Branch of Feather River at a mean elevation approximating 1,900 feet. Lying on the Butte County Railroad 15 miles east of Chico, it is off the main lines of travel but still has rail communication with the centers. Production is mainly deciduous fruits and berries and with additional water the district could be cultivated nearly to the limits of its acreage. The present supply comes mainly from Little Butte Creek through a small ditch owned by the Oro Water, Light and Power Company, this ditch gaining the ridge near Magalia, where it irrigates about 600 acres, and then continues to join a ditch from West Branch of Feather River furnishing water for power and irrigation about Oroville. An additional small supply, irrigating 90 to 100 acres about Magalia, is obtained from the old Cherokee Mining Ditch, owned by the Pacific Gas and Electric Company. Cherokee Ditch obtains water from a branch of Big Butte Creek opposite Powelton and carries it to Spring Valley Reservoir across West Branch of Feather River near Concow, the only present use being that for irrigation near Magalia. A large supply of irrigation water per acre is not needed on Paradise Ridge and there is probably a sufficient annual run-off from 13 square miles on Little Butte Creek alone to supply the entire area if it could be stored and power rights were not conflicting. Even if Little Butte Creek should fail to furnish enough water its flow could be supplemented by diversion into it of some small tributary of West Branch of Feather River on the north and east. Or, with cheap power, there seems no reason why some water can not eventually be pumped from West Branch of Feather River at some point between Paradise Ridge and Stirling from which a gravity conduit could carry it economically to the ridge. One privately surveyed storage site is available on Little Butte Creek a short distance above Magalia which, if available to Paradise Ridge, would care for much of the present shortage. Other sites are also undoubtedly at hand. Taken altogether, as deciduous fruits justify a considerable expense for water, it seems reasonable to class all of the Paradise Ridge as ulti-

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mately irrigable. One acre-foot per acre per year delivered at the small holdings would suffice for most of the area if only that amount could be furnished economically.

WYANDOTTE-BANGOR AREA.

East of the plains country about Oroville and Palermo and north of Honcut Creek, in the general vicinity of Wyandotte and Bangor, and below the 1,000-foot contour, 38,000 acres of rolling foothills that are now partially covered by the South Feather Land and Water Company have been classed as irrigable. This land is covered with the scrub oak, chaparral, and digger pine characteristic of the low Sierra foothills and when cleared and irrigated is considered very satisfactory for the growth of both deciduous and citrus fruits. Present cultivation extends up to elevations of 900 and 1,000 feet, and in 1912, 1,395 acres were reported irrigated. The water supply of this area now comes from Lost, Orleva, and Pinkard creeks, all tributaries of South Fork of Feather River, Lost Creek being most dependable for summer flow. It is locally estimated that 5,000 acres are susceptible of irrigation through the Forbestown Ditch and its branches of the South Feather Land and Water Company. The normal rainfall at Oroville, seven miles west of Wyandotte, is 28.4 inches, and the rainfall on the watershed of the creeks supplying the area is above that. Irrigation here will be involved with irrigation in the Palermo section. A watershed of 107 square miles is tributary to South Fork of Feather River above the latter, and with two thirds of the average rate of run-off of the entire Feather above Oroville, this would supply 128,400 acre-feet of water per annum if it could all be conserved. What proportion of the available supply can be used in the Wyandotte-Bangor area, however, cannot be satisfactorily estimated. In addition to South Fork and its tributaries, Honcut Creek and its numerous branches passes through the area and if storage is feasible on it, could be made to add to the supply if its use were not forced lower down on the plains and small bottoms about Honcut.

BROWNS VALLEY AREA.

This is an area of indeterminate extent of which 25,000 acres centering about 15 miles east of Marysville are classed as irrigable. The lands here have an elevation of 300 to 500 feet and possess physical conditions similar to those of the Wyandotte-Bangor area adjoining it above Honcut Creek directly to the north. Between 1888 and 1893 approximately $175,000, in bonds, was spent through the medium of Browns Valley Irrigation District to supply water to this area from North Fork of Yuba River. At present only 1,750 acres are irrigated and this area receives water by virtue of a contract with the Pacific Gas and Electric Company in accordance with which that company maintains and operates the district canals in conjunction with a power installation above the irrigable lands, and at an annual cost to the irrigators of $3 per miner's inch. The main ditch of Browns Val-

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ley District heads in North Fork of Yuba River a short distance above the latter's junction with Middle Fork, the tributary watershed above the point of diversion being 490 square miles. The measured discharge of Yuba River at Smartsville for the years 1903 to 1910[1] shows a mean annual run-off for the entire Yuba of 2,640 acre-feet per square mile. If this mean can be applied to North Fork the annual run-off above Browns Valley Ditch is 1,790,000 acre-feet. There can be no question that water is available for the entire irrigable portion of the Browns Valley area if the course of development permits its use there.

NEVADA CITY-SMARTSVILLE AREA.

Between Yuba and South Fork of Yuba and Bear rivers, and extending in regular and broken patches from the Sacramento Valley plains to an elevation of 2,500 feet east of Nevada City and Grass Valley, 106,000 acres are more or less roughly estimated as agricultural and within the general range of water for irrigation. Of this 4,013 acres is now reported irrigated, of which 1,000 acres is under the ditches of the Excelsior Water and Mining Company along the ridges from Smartsville to Nevada City. Some land is also watered south of Smartsville about Spenceville and Cabbage Patch, as well as along Wold Creek and its tributaries south of Grass Valley. With the exception of a small acreage about Smartsville and Cabbage Patch in Sacramento County, all of the area is in Nevada County. An additional area of 11,000 acres of the same character lies between Middle and South forks of Yuba River, also in Nevada County, from North San Juan east to Paterson and south of French Corral.

The entire Nevada City-Smartsville area is still more devoted to mining than to agriculture, the principal ditches carrying more water for the former purpose than the latter. While the normal rainfall at Nevada City has been more than 55 inches for a period of nineteen years, the rapid run-off, relatively shallow mountain soils, and summer droughts make irrigation necessary. The crops grown are alfalfa and wild grasses on the lower lands and grain, hay, deciduous and some citrus fruits, and small gardens, all chiefly for local consumption. The water supply now diverted to the area comes partly from many small creeks but mainly from South Fork of Yuba River. The principal creeks furnishing irrigation water are Deer Creek above Nevada City, Squirrel Creek, in Penn Valley, and Wolf Creek, south of Grass Valley. Excelsior Water Company claims all of the water of Deer Creek and in South Yuba River and tributaries below or west of the South Yuba Water Company's system. The annual yield of South Fork of Yuba River above the heading of Excelsior Ditch, at the average yield per square mile for the entire Yuba of 2,640 acre-feet, is enough for irrigating all of the area tributary to its ditches but it will not all be used there. Improvements under way in 1911 contemplated making the system susceptible of irrigating 5,000 acres. It has further been estimated that with the future decline of mining 40,000 acres can

[1]U. S. Geol. Survey Water Supply Paper 298.

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be brought under the system, but this is probably an excess figure. For the area about North San Juan only small local streams are economically available for irrigation. For the areas about Cabbage Patch and Spenceville and along Wolf Creek, Bear River might be diverted but the use of that stream, whose summer flow is small, is not likely on these high areas. If 25 per cent of the agricultural land in the Nevada City-Smartsville area, or approximately 30,000 acres, is eventually irrigated, development will then have reached the limit of what now seems reasonably to be expected.

PLACER COUNTY FRUIT DISTRICTS.

South of Bear River and north of North Fork of American River the Sierra foothills have reached their highest agricultural development in northern California. The arable foothill lands between these two streams are similar to those north of Bear River, but the presence of more of the old mining ditches and of more accessible railroad transportation have resulted in a very much larger area being brought under irrigation. Of 134,000 acres classified as arable between these two rivers, 104,000 acres embrace the Placer County fruit districts that are now irrigated to the extent of 14,000[1] acres by the various conduits of the South Yuba Water Company, owned by the Pacific Gas and Electric Company. The water supply of South Yuba Water Company, which is used for power as well as for irrigation, comes from Bear and South Yuba rivers, and is distributed through twenty lakes and reservoirs, with a capacity of 46,500 acre-feet, and 265 miles of ditches and pipe lines, the present total diversions being 130 cubic feet per second. From the various sources and storage reservoirs, the collected waters pass to Lake Spaulding, which has been acting as the final storage and distributing point of the system. The enlargement of the Lake Spaulding storage to a capacity of 91,800 acre-feet is now in progress in connection with the hydroelectric development of the Pacific Gas and Electric Company, and the water, after use in generating power from this and the other storage is to be returned to Bear River for re-diversion for irrigation purposes. The total quantity to be diverted by the company under its enlarged development will be 350 cubic feet per second. After re-diversion from Bear River the water is to be used on about 35,000 acres between American and Bear rivers and on areas extending from Applegate to Roseville and Lincoln.

The Placer County fruit district, of which the main towns are Newcastle, Auburn, Penryn, Loomis, and Rocklin, is the largest center of mountain fruit growing in California. Although a 40-year rainfall record at Auburn shows a mean annual precipitation of 35.13 inches, irrigation is necessary owing to the steep ground slopes and the relatively shallow soils. With small quantities of water—the duty is claimed to average 1 inch to 7 acres—fruit growing is successful. Water is sold to irrigators in these districts at the flat rate of $45 per miner's

[1]Later data shows the irrigated area in 1912 to be 15,000 acres.

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inch per year, and is used by the irrigators in small continuous stream and distributed to the orchards in contour furrows.

A 50 per cent development in these fruit districts would more tha treble the present irrigated area.

ORANGEVILLE-FAIR OAKS AREA.

This is a continuation of the foothill area of the Placer County frui districts, lying north of American River in Sacramento County, begin ning about 10 miles northeast of Sacramento. The slopes are les steep here than in the foothills farther north. Approximately 29,00 acres are embraced in the area, of which 4,450 are reported irrigated Aside from springs and a few small creeks watering about 450 acres the main water supply now available to the area is that of the Ameri can Canyon Water Company. This company obtains water fron North Fork of American River southeast of Auburn which it deliver through three reservoirs, 25 miles of main canal, and 27 miles o steel pipe to Orangeville and Fair Oaks colonies. Of 4,000 acres irri gated in these colonies, approximately 3,200 acres are in orchards largely citrus, 200 acres in vineyards, 80 acres in alfalfa, and th remainder in lawns, gardens, and berries. In all, 11,000 acres in th two colonies are now piped for water distribution.

Ultimate irrigation development here as elsewhere in the foothill depends on the water supply that can be made available from the larg streams. Gagings are not at hand for North Fork of American River but the Geological Survey record for the entire American River a Folsom shows an average annual run-off per square mile of watershe of 1900 acre-feet, over one half of the total watershed of 1,910 squar miles being on North and South forks. But while the annual flow o North Fork of American River is large, the summer flow is small an adequate for only a relatively small area without storage, and no dat are at hand with reference to the possibilities of that. As in the Place County fruit districts, water is distributed to orchards here in contou furrows, but at present under a flat annual acre charge of $3.

AREAS BETWEEN AMERICAN AND COSUMNES RIVERS.

South of North and Middle forks of American River and north o the Cosumnes 216,000 acres have roughly been classed as agricu tural land by throwing out all land known to be too rocky or to steep for cultivation below an elevation of 2,500 feet. Adjoining th Sacramento Valley plains areas is a large area of now barren an slightly rolling land of which part is devoted to grain growing and larger acreage to grazing. From there to an elevation of 2,500 feet th area is very much broken and only the tops of the ridges and thei more gently sloping sides are susceptible of cultivation. Between Mid dle and South forks of American River 42,000 acres of the total ar situated, the center of this area being Georgetown. In 1911 the are reported irrigated there was 1,546 acres, supplied by the Loon Lak Water and Power Company, one branch of their system extending to th

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vicinity of Cool and another to Garden Valley and Kelsey. The Loon Lake Company contemplates considerable storage and estimates that their system can be extended to cover 15,000 acres. Between South Fork of American River and Weber Creek are 26,000 acres of agricultural land with Placerville the main center. Here the Sierra Water Supply Company furnish water for approximately 1,000 acres in the vicinity of Placerville and Granite Hill. The diversion of this company is from South Fork of American River 31 miles above Placerville and their distribution is mainly through old mining ditches as elsewhere in the foothills. The Ranchers Ditch Company irrigates about 200 acres in the vicinity of Coloma, and an additional scattered irrigated area of 413 acres is reported. The mean annual precipitation at Placerville covering a period of 34 years is 45.59 inches and profitable agriculture is possible without irrigation, but irrigation here as elsewhere in the foothills is necessary for commercial fruit growing and its considerable extension is looked for. The remainder of the agricultural lands between American and Cosumnes rivers, aggregating approximately 148,000 acres, extend from Folsom to Pleasant Valley. At present 1,100 acres are reported irrigated. The land nearest the Sacramento Valley plains is generally shallow and not promising for irrigation development, but from Shingle Springs to Pleasant Valley, at elevations of 1,500 to 2,500 feet, better areas are found. The Diamond Ridge ditches, forming the Crawford Ditch system, now water about 500 acres near Diamond, El Dorado, and Shingle Springs by diverting water mainly from North Fork of Cosumnes River at Steely's Ford but also, en route from Camp, Clear, Squaw Hollow, and other creeks. This system comprises about 80 miles of main ditches and laterals originally used exclusively for mining and thus covers a rather extensive territory in which water will be more and more used for irrigation.

IONE-JACKSON AREA.

Another large and undeveloped foothill area, with the roughly classified agricultural lands scaling to 220,000 acres, lies south of Cosumnes River in Sacramento and Amador counties. At present the irrigated area reported is only 630 acres with but little further development active. Much of the soil roughly classified as agricultural, like much of that in the foothill areas farther north, is too thin for satisfactory cropping, but when the soil is sufficiently deep all kinds of deciduous fruits are successfully grown in small family orchards and flourishing vineyards are to be seen on the hillsides near Jackson. Mining still predominates in Amador County. The greatest present agricultural growth is in Jackson and Ione valleys, together comprising about 18,000 acres, along Jackson and Sutter creeks. Alfalfa is grown without surface irrigation along the main creek bottoms, but grains form the main crops and stockraising is the chief agricultural industry. More intensive development has been retarded here by large holdings. Counting Cosumnes and Mokelumne rivers, with mean annual dis-

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charges at the gaging stations of the Geological Survey at Michigan Bar and Clements of 571 and 1,440 cubic feet per second, respectively, or of 404,000 and 1,040,000 acre-feet,[1] there is a large supply of water tributary to this area. What portion of this is to be stored and used in the foothills rather than in Sacramento and San Joaquin valleys cannot be estimated. A number of water systems are operating in this area, owned principally by the Pacific Gas and Electric Company, the Amador and Volcano Mining and Land Company, Hayward, Hobart, and Lane, and the Lancha Plana Irrigation and Mining Company. These systems are chiefly used for mining or power and irrigation under them is incidental only. It may reasonably be assumed that eventually there will be such reorganization and readjustment of these systems as to result in a larger quantity of water controlled by them being used for irrigation, but until this is accomplished no irrigation extension will be possible other than such as will result from small storage on the numerous lesser streams of the area, of which there are many.

SUMMARY.

More than three quarters of a million acres of agricultural land is the estimate that has been made for the Sierra foothills of northern California of which 45,259 acres are now reported irrigated. In nearly every section included the annual water supply is more than sufficient for irrigating the arable areas found, but difficulties of diversions, uncertainties as to storage possibilities, power and mining development in the foothills themselves, and the certainty of large use of the Sierra streams for irrigation in Sacramento Valley render hazardous any estimate of ultimate irrigation development. No more than reasonable difficulties and complications however seem in the way of future increase in the irrigated area to between 150,000 and 200,000 acres.

SACRAMENTO VALLEY.

This main division of northern California is taken to include (1) Sacramento Valley proper, extending from Red Bluff south to the mouth of the Sacramento at Collinsville, and including both valley floor and adjacent valley plains; (2) broken areas about Redding and along the Sacramento and its upper tributaries other than Pit and McCloud rivers and the streams of the Whitmore foothill area; and (3) the rolling agricultural foothills or upper valley plains bordering the west side of Sacramento Valley south to Cache Creek. This classification puts into the Sacramento Valley division the territory broadly considered as forming Sacramento Valley, with the addition of the scattering bottoms and plains about Redding. Such areas as those at Browns Valley, Rocklin, Orangevale, and Fair Oaks, although not far removed from the valley, are still more properly treated with the Sierra foothills.

[1] U. S. Geol. Survey Water Supply Paper 299.

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DESCRIPTION.

While the detailed study of soils has not been part of the investigations with which this report deals,[1] a brief statement of the varying soil conditions in Sacramento Valley and their topographic occurrence is necessary to an interpretation of present and a general understanding of probable future development under irrigation.

The valley plains—These are the gently undulating, sometimes "hogwallow," talus lands bordering the eastern edge of the valley and the sometimes more rolling and generally more elevated areas forming the western edge. On the east side, and north of Stoney Creek on the west side, these plains areas are characteristically red or reddish, gravelly, and generally of heavy or compact subsoil, the latter often being a tough hardpan that only dynamiting renders fit for tree growth. Southeast of Red Bluff and northwest of Oroville much of the plains is nonagricultural, except for grazing, because of lava, and in some other sections the presence on the surface of cemented gravel renders them unfit for cultivation. South of Stoney Creek on the west side the so-called plains are themselves either the low eastern ridge of the Coast Range foothills or the washings from them. They are made up of grayish and brownish soils of more uniform character and greater depth. While, as indicated, the Sacramento Valley plains are in places of low, if any, agricultural value, on the whole they constitute a thermal zone of high horticultural value within which the growth of such fruits as oranges, lemons, olives, and almonds has proven very profitable. At present the chief intensive development of the plains lands is in the orchards about Oroville and Corning, and the recent citrus plantings west of Maxwell, noted elsewhere in this report, point the way toward development on the west-side plains that is likely to be limited only by the economic availability of a water supply for irrigation. From Red Bluff south the total area of the plains, including the slightly wooded areas west of Tehama and Arbuckle, scales 346,700 acres on the east side and to 326,300 acres on the west side, the latter not including the higher and steeper of the bare hills, as those west of Norman and Delevan, but otherwise extending to the rocky, broken, and wooded foothills of the Coast Range. The line dividing the valley plains and the foothills is usually not difficult to draw, but in some cases that between the plains and the valley, especially south of Marysville, can only be arbitrarily assumed. Most frequently, however, the plains form a distinct step above the valley floor that is sometimes only slight, although frequently abrupt.

Main valley floor—Below the plains lie the upper lands of the main Sacramento floor. Not all of these are alluvial, which might be considered as limiting real valley land. On the contrary, in addition to the rich alluvium of the Sacramento River bottoms and the immediate

[1]See special report on physico-geographical and agricultural features of California, by E. W. Hilgard, in report to the superintendent of the census, dated June, 1883 (Government Printing Office, 1884), and U. S. Dept. Agr., Bureau of Soils, soil surveys of Redding, Red Bluff, Colusa, Woodland, Marysville, and Sacramento areas.

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bottoms of some of its tributaries, the main valley floor is taken to include the only partly alluvial bottoms of some of the other tributaries and the lower elevations of what a classification strictly according to soil types would include as plains. What might be called the lower plains, because their soils more resemble the gravelly loams of some of the upper plains than the fine silts of the immediate river bottoms, are herein considered part of the main valley floor, because in general they have similar growing and water conditions and require similar methods of agricultural treatment. While the main valley floor contains some soils that are at present of low-producing value, as the "goose" lands south of Willows, or difficult to crop, as the heavy black adobes south of Durham, they are as a whole both deep and rich and readily respond to good methods of cropping, tillage, and irrigation. They have been the main source of the enormous yields of grain that brought prosperity to this portion of California for fifty years after farming began in the State, as they will be the main scene of general irrigation farming in Sacramento Valley in the future. Counting approximately 535,000 acres on the east side and 424,500 acres on the west side subject to temporary and intermittent overflow in periods of flood flow in the Sacramento and its main tributaries, and including the overflow lands, the main valley floor scales to 1,346,800 acres between the river and the plains on the east side and to 1,286,200 acres between the river and the plains on the west side—a grand total of 2,633,000 acres. Of these areas of overflow lands, 136,500 acres on the west side and 163,100 acres on the east side are embraced in reclamation districts or are under private reclamation.

The basin and island lands—The main Sacramento Valley floor as above defined is not a continuous body of irrigable land from the plains on the east to the plains on the west, but is interrupted by the basin and other overflow lands on each side of the river below and about the line between Glenn and Colusa counties, and by the islands in the river delta region above Collinsville. From Stoney Creek, the beds of Sacramento River and of the lower portions of its main tributaries are higher than the adjacent lands, and during flood periods of late winter and spring the streams seek relief through five main depressions or basins, namely, Colusa and Yolo basins on the west side of the valley, and Butte, Sutter, and American basins on the east side. The result of the streams thus leaving their channels is the permanent or temporary submergence of 800,000 acres during every considerable flood and of 1,088,000 acres during extraordinary floods,[1] these acreages including the sloughs and side channels at the mouths of both Sacramento and San Joaquin rivers near Collinsville. Of the zone thus within the paths of the overflow, something over 300,000 acres have been wholly or partially reclaimed by dyking, 47,000 acres are classed on the latest topographic map of the valley as salt marshes, and 50,000 acres as fresh

[1] 62d Congress, 1st Session, House Document No. 81, Reports on the control of floods in the river systems of the Sacramento Valley and the adjacent San Joaquin Valley, California.

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water marshes, leaving 691,000 acres, approximately, still subject to occasional flooding. While leveeing costing nearly twenty million dollars has been done along the Sacramento and its main tributaries, no comprehensive or consistent scheme or reclamation has yet been put into effect, the result being frequent disaster, each new reclamation by so much restricting the free escape of the floods to Suisun Bay.[1] Much study has been given to comprehensive plans of leveeing and it is now hoped to carry out a project prepared by the California Débris Commission,[2] that will result in the permanent reclamation of 400,000 acres more swamp land and the permanent protection of the lands now subject to temporary overflow. The latter is to be accomplished by carrying levees along the main sloughs and streams entering the basins, from the by-passes to high ground, and by supplying culverts or pumps to remove the surface water accumulating above the levees. When this project shall have been carried out, the area, principally between levees, that will still remain non-agricultural because of being occupied by stream and flood and other drainage channels will approximate 250,000 acres, and the total area of reclaimed land will approximate 750,000 acres.

CONDITIONS OF DEVELOPMENT IN SACRAMENTO VALLEY.

While the irrigable areas of Sacramento Valley are treated below in some detail, both as to their character and water supply and their present and possible irrigation, some generalizations seem in place here as to the conditions and trend of development in the valley.

Sacramento Valley, although the best watered of any large irrigable area of California, is in the paradoxical situation of being the least irrigated. With a large expanse of land suited to receive water, and in general every condition of soil and climate present that is favorable to intensive and varied culture under irrigation, the total acreage in the valley yet watered is less than is irrigated under a number of single canal systems elsewhere in the State. Many conditions are responsible for this slow growth. In the first place, favorable winter temperatures and a normal rainfall averaging approximately 20 inches, of which more than 80 per cent falls from October to March, has permitted the profitable raising of grains during the winter and spring months without irrigation, and the large land holdings have made such farming

[1] It is estimated in the report of the California Debris Commission that in the flood of January, 1909, the loss in 41 of the 48 reclamation districts then in existence was over $4,500,000, and that the losses throughout the valley due to the floods in 1904, 1907, and 1909 amounted to at least $11,000,000.

[2] For account of reclamation work in Sacramento and San Joaquin valleys, abstracts of reclamation laws, and investigations of State and Federal governments see House Documents 1123 and 1124, 60th Congress, 2d Session; House Documents 76 and 81, 62d Congress, 1st Session; Report to the Commissioner of Public Works of California by Dabney Commission, 1904; Report of Commission of Public Works of California, 1894; and Transactions Commonwealth Club of California, Vol. IV, No. 5. The method of control recommended by the California Débris Commission is the improvement of the present main channel for navigation, with by-passes through Butte, Sutter, and Yolo basins for maximum floods, the by-passes being leveed and covering 78,000 acres of agricultural land, of which 38,000 acres could be partially cultivated. The estimated areas in each basin covered by the by-passes are Butte, 7,570 acres; Sutter, 13,970 acres; and Yolo, 56,545 acres. The estimated cost is $33,000,000, of which it has been recommended that the benefited areas pay one third, the State of California one third, and the Federal Government one third.

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both attractive and profitable to those accustomed since the bonanza days to large-scale operations. When fruits and alfalfa have been planted on the alluvial lands of the valley floor, and in some cases even on the plains, they have produced so well without irrigation that many have been led to believe that the expense involved in getting a water supply for irrigation would not be justified by the additional returns irrigation would bring. And even with irrigation accepted as desirable, to obtain a water supply even in a valley so lavishly watered as the Sacramento has involved an effectiveness of association on the part of the landowners that could not be expected in a section so sparsely settled. Knowledge about underground sources, which are closest at hand, has been meager; in fact, outside of the valuable citrus orchards of the south, the economical justification of pumping water for irrigation has only been generally appreciated within the past decade. The value for irrigation of the streams entering the valley from the Sierra or coast ranges has always been understood, but the water laws of the State have so permitted the control of some of them, either by riparian proprietors or appropriators who have neither fully used them nor permitted others to do so, that irrigation development approaching the capacity of such streams has been out of the question. The only water sources in Sacramento Valley whose use has not been retarded by the adverse interests mentioned are the main Sacramento and the Feather and the American, the two larger tributaries of the east side. In the case of the Feather and the American, only the natural slowness of irrigation extension common to Sacramento Valley or the absence of ample low-water flow at points of economical diversion, has held back use. In the case of the Sacramento, the interests of navigation, whose tonnage now aggregates approximately thirty million dollars per year, have stood as an obstacle to irrigation. Although it is doubtful if any proper diversion for irrigation would have been prevented in the interests of navigation, the large additional use of this river will involve not only storage on the Pit to obtain a late summer flow, but also diversion so long and so expensive as to require attractions to capital that apparently do not now exist; or in lieu of that, a strength of organization under the irrigation district law that will be difficult of accomplishment with water available to many from underground or Coast Range sources. Sacramento River lies separated by Colusa and Yolo basins from the higher grounds on the west side below Stoney Creek that are in most need of it, rendering all-gravity or pump and gravity diversions below Central Canal possible only to the lands immediately bordering the river. With storage on the Pit and Feather, water is likely always to be available in the river opposite Colusa and Yolo basins, but the pumping of water across these basins to even the lands of the main valley floor is not yet looked upon as feasible, and probably will not be attempted on a large scale until all underground sources are exhausted and all practicable or economical diversion is effected from Sacramento through or above Central Canal. Nevertheless, if the west-side plains prove as profitable for citrus orchards as the experienced growers who

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are now starting large plantings on them west of Maxwell believe, and if water is not available from other sources, it is at least conceivable that pumping across the basins to these higher areas will eventually be resorted to, regardless of the fact that such procedure would at present be considered far in advance of economical development.

WATER SUPPLY OF SACRAMENTO VALLEY.

Although the water supply available to the different unit areas of Sacramento Valley as they have been segregated for treatment is discussed below in connection with such areas, a general summary of known data regarding it seems in place here.

The water resources of Sacramento Valley are the largest in the State, the estimated mean annual run-off of the Sacramento and tributaries being approximately twenty-six million acre-feet. General studies of these resources have been made both in connection with flood control and irrigation, these studies including stream gagings and examinations for reservoir sites on all of the larger streams.[1] The following summary of stream-flow records, taken from the reports of the United States Geological Survey and of the California State Engineering Department, give the mean monthly and annual discharge for the principal streams of the valley for the years down to and including 1910 for which records are available:

[1]U. S. Dept. Agr., Office Expt. Stas. Bul. No. 207; U. S. Reclamation Service, 5th Annual Report; House Doc. 81, 1st Session, 62d Congress, Reports on control of floods in the river systems of the Sacramento Valley and the adjacent San Joaquin Valley, Cal.; Reports of California Commission of Public Works, 1894 and 1905; U. S. Geol. Survey Water Supply Paper No. 298.

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Table showing drainage areas in square miles and the mean monthly and annual flow in cubic feet per second of streams in Sacramento Valley, 1875-1910.

Stream and point of measurement.	Number of years.	Drainage area. Square miles.	Mean flow in cubic feet per second.													Total mean annual run-off. Acre-feet.
			October	November	December	January	February	March	April	May	June	July	August	September	Mean flow.	
Sacramento River at Red Bluff	16	9,300	5,800	9,450	12,000	22,500	32,600	29,900	19,500	14,700	9,190	6,110	5,180	5,090	14,300	10,400,000
Sacramento River at Collinsville[1]	7	26,200	7,920	8,460	17,300	39,000	40,100	56,400	84,600	83,900	55,700	21,400	9,570	6,810	35,900	26,000,000
Stoney Creek at Fruto	10	600	64	339	525	1,910	2,670	2,300	1,060	497	180	36	12	14	802	581,000
Feather River at Oroville	9	3,640	1,930	4,540	4,920	10,900	14,000	19,200	17,400	12,900	7,560	3,080	1,820	1,600	8,320	6,020,000
Yuba River near Smartsville	7	1,220	657	1,730	2,420	7,170	7,890	9,840	8,480	7,790	4,840	1,490	543	476	4,440	3,220,000
Bear River at Van Trent	6	263	98	73	338	1,880	1,380	1,760	678	388	227	58	32	33	574	416,000
Cache Creek at Yolo	8	1,230	41	77	250	1,790	2,800	2,890	1,940	957	462	202	79	22	960	695,000
Putah Creek at Winters	5	805	11	24	312	3,010	2,150	2,170	544	181	97	26	12	9	712	515,000
American River at Fair Oaks	6	1,910	396	1,150	2,410	8,350	7,940	10,900	9,590	9,240	7,100	2,710	635	330	5,060	3,630,000
Cosumnes River at Michigan Bar	3	524	33	96	371	2,030	1,370	1,370	909	472	161	26	4	7	571	404,000

[1]California State Engineering Department, 1878-85.

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An examination of the above summary shows that large as is the water supply tributary to Sacramento Valley, the distribution of run-off is not favorable to direct diversion for irrigation. The main irrigation season is from April to September, the time of its beginning and ending depending on the spring rains and the extent of water available in the late summer and fall. March is the month of maximum run-off, with 19 per cent of the total, but irrigation is not practiced to any considerable extent, and usually not at all, in that month. By June, when heavy irrigation should begin, the run-off falls below the mean for the year. By the end of July it is down to approximately 10,000 cubic feet per second, and throughout August and September it is below that figure. A glance at the table shows that the mean flow of the Sacramento at Collinsville for August and September is 9,570 and 6,810 cubic feet per second, respectively. In 1908, the minimum year covered by the records, the total mean discharge of the measured streams was only 12,500,000 acre-feet, or 49 per cent of the mean of 26,000,000 acre-feet.

STORAGE FOR SACRAMENTO VALLEY.

The lack of available water for irrigation by diversion of natural flow during the summer months shows that storage will be necessary before large irrigation development can take place in Sacramento Valley. The available data regarding storage sites therefore become of prime interest. A summary of these, taken from Fifth Annual Report of the United States Reclamation Service, is inserted below. The sites listed do not include numerous sites already utilized on the Sierra streams, but without those they have estimated amounts annually available to them from their tributary watersheds of 3,390,184 acre-feet.

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Summary of data regarding available storage on Sacramento Valley streams.

Name of reservoir.	Description.	Capacity of reservoir basin as surveyed.	Probable amount available annually from watershed.
		Acre-feet.	Acre-feet.
Guenoc	Putah Creek	188,000	80,000
Monticello	Putah Creek	130,000	130,000
Clear Lake	Cache Creek	100,000	100,000
Little Indian Valley	Cache Creek	76,500	50,000
Briscoe	Stony Creek	14,385	14,385
East Park	Stony Creek	26,000	26,000
Mill Site	Stony Creek	43,735	43,735
Iron Canyon	Sacramento River	226,900	226,900
Jess Valley	South Fork Pit River	224,560	----------
West Valley	South Fork Pit River	94,579	----------
Warm Spring Valley	Pit River	559,015	----------
Round Valley	Ash Creek	184,732	----------
Big Valley[1]	Pit River	3,196,188	[2]1,000,400
Big Meadows	North Fork Feather River	780,384	780,380
Indian Valley	Indian Creek	688,000	500,000
Concow	North Fork Feather River	10,012	10,012
Butte	North Fork Feather River	107,000	107,000
American Valley	North Fork Feather River	86,055	86,055
Spanish Ranch Valley	North Fork Feather River	8,469	8,469
Buck Valley	North Fork Feather River	37,843	37,843
Grizzly Valley	Middle Fork Feather River	61,820	20,000
Mohawk Valley	Middle Fork Feather River	12,626	12,626
Oregon House Valley	North Fork Yuba River	90,823	90,823
Greenwood	American River	65,952	65,952
Totals		7,013,578	3,390,184

[1]Big Valley reservoir site is below Jess Valley, West Valley, Warm Spring Valley, and Round Valley reservoir sites.

[2]This estimate includes discharge from Goose Lake drainage.

Where storage capacity is greatly above the supply probably available annually, as is strikingly true in the case of Big Valley, the excess years would enable additional amounts to be carried over to the years of less yield. All of the reservoir sites listed can not be considered as available for irrigation in Sacramento Valley, for their use for that valley must be contingent on both power and irrigation rights on the upper streams, and on such conditions of navigation on Sacramento River as the United States decides to maintain. Power uses adverse to irrigation have not yet been felt on the west-side streams or on the main Sacramento, but they are becoming of importance on the east side. These and other matters relating to water supply are considered in detail in connection with the unit areas of the valley.

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SUMMARY OF AGRICULTURAL AND IRRIGATED AREAS.

The following table summarizes the agricultural and irrigated areas of the Sacramento Valley division as they were segregated by county, hydrographic, or other lines for field study:

Summary of agricultural and irrigated areas in Sacramento Valley.

Area.	County or counties.	Valley agricultural land. Acres.	Plains agricultural land. Acres.	Area irrigated. Acres.
Redding	Shasta and Tehama	24,000	55,000	4,080
Happy Valley	Shasta and Tehama	----------	62,000	1,628
West Side:				
Red Bluff–Corning	Tehama	87,000	137,000	4,500
Orland	Glenn	79,000	32,300	5,300
Stoney Creek	Glenn	3,000	----------	2,250
Willows	Glenn	186,000	40,000	6,000
Colusa	Colusa	330,000	39,000	7,875
Woodland	Yolo	400,000	78,000	14,570
Capay Valley	Yolo	10,000	----------	160
Solano	Solano	157,000	----------	2,527
Vaca Valley	Solano	7,000	----------	50
Suisun	Solano	30,000	----------	278
East Side:				
Red Bluff–Vina	Tehama	34,500	29,000	9,600
Chico	Butte	138,000	15,200	800
Glenn-Colusa east side	Glenn and Colusa	82,500	----------	----------
Feather River	Butte	266,000	86,000	17,190
Sutter Basin	Sutter	158,000	----------	218
Yuba	Yuba	113,000	14,500	4,186
Sacramento–Lincoln	Sutter, Placer and Sacramento	246,000	94,000	225
Sacramento–Galt	Sacramento	236,000	108,000	13,000
Lower Sacramento River islands	Sacramento	72,000	----------	28,272
Scattering, unlocated	----------	----------	----------	791
Totals	----------	2,659,000	790,000	123,500

REDDING AREA.

This includes the scattering areas of alluvial bottom lands along Sacramento River and tributaries between Redding and Red Bluff, aggregating 24,000 acres. It also includes the gravelly plains and lower foothills adjacent to the bottoms, aggregating 55,000 acres. Beginning at the north, the bottom areas are along Churn, Stillwater, and Cow creeks and Sacramento River, east and south of Redding; along Sacramento River and Clear, Cottonwood, and Bear creeks, near Anderson and Cottonwood, and along Sacramento River and lower Paynes Creek, between Anderson and Red Bluff. The creeks east of Redding flow through Stillwater and Millville plains, which are elevated areas of an entirely different character from the narrow creek bottoms. These plains are agriculturally similar to the plains on the east side of Sacramento between Oroville and Chico and thereabouts.

The valley lands in the Redding area are mostly all cultivated. As a rule, irrigation is not practiced, the watered area being only 4,080 acres, lying mainly along Cow Creek and tributaries, Clear Creek, and the lower portion of Paynes Creek near Bend. The first-bottom lands

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are usually devoted to alfalfa. On some of the lands above the low first bottoms, particularly along Churn Creek and along Sacramento River near Anderson, deciduous fruits predominate. The remaining cultivated lands, generally 50 to 75 feet above the adjacent streams, are still devoted to grain growing. Neither the deciduous fruits nor the grains are irrigated. The lands of the Millville and Stillwater Plains are mostly not cultivated, owing to the impossibility of profitable cropping without irrigation and the absence of an immediately available gravity water supply.

While, aside from on Sacramento River, no stream gagings are available for this territory, there is ample water at hand, if storage is feasible, for irrigating all of the valley land present, either by gravity flow or by pumping. The streams considered above are all perennial and largely within economical reach of the lands to which they are tributary. All of the bottom lands here are not greatly in need of more water, the normal rainfall at Redding, based on a 26-year record, being 36.11 inches and that at Red Bluff being 26.11 inches. With such annual precipitation, in spite of the fact that the summers are dry, deep-rooting crops generally receive ample moisture. The higher lands now devoted to grain growing, however, can and eventually will be made to produce the more valuable crops that irrigation will benefit. Power filings and contemplated development on the streams in this area contribute an element of uncertainty as to their ultimate use for irrigation.

HAPPY VALLEY AREA.

This includes, roughly, 62,000 acres of rolling and elevated plains west of Anderson between Cottonwood and Clear creeks. While known as Happy Valley, the area contains no real valley land and is rather a ridge than a valley. The soil is a gravelly loam underlain at varying depths with hardpan and cut at frequent intervals along the edges of the area with small dry gullies. The section has been crippled by fumes from the copper smelters at Keswick, Coran, and Kennett, both native and planted vegetation having been affected prior to the control of the smelter fumes under court orders. The crops grown are olives, peaches, berries, and vegetables, all mostly irrigated. The present water supply is mainly furnished from North Fork of Cottonwood Creek by Happy Valley Land and Water Company, which at present irrigates 1,578 acres. This company is a coöperative irrigation association that succeeded to the field of the Happy Valley Irrigation District when it failed of organization in the nineties. The water conduit in use is that of an old mining company, whose rights the present company purchased. Another small coöperative association irrigates 50 acres near Ono through Bee Creek Ditch. The areas these two ditches are claimed to be intended ultimately to cover are 20,000 and 300 acres, respectively. Under Bee Creek Ditch, however, a

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considerably larger area might be irrigated under less wasteful use than now occurs.

Besides North and Middle forks of Cottonwood Creek, Bee Gum, Jerusalem, and Clear creeks are the streams tributary to the Happy Valley area. Clear Creek is now used in summer for irrigating 1,100 acres under the Townsend Flat Ditch, in the Redding Area, but with storage and economical use part of its flow could be made available to Happy Valley. Middle Fork of Cottonwood Creek and the main Cottonwood below the forks could most economically be used on the bottom and low bench lands along the latter stream, but if not used there it is feasible to carry water from the north fork to Happy Valley. Unfortunately no gagings are available for any of these streams. Without storage, but little irrigation increase is likely, but with storage feasible, as to which no data are available, much additional development would be possible. If the expense of diversion from Sacramento River near or above the mouth of the Pit were justified, water for at least all of the lower portion of the area would be available there.

WEST SIDE OF SACRAMENTO VALLEY.

RED BLUFF-CORNING AREA.

This comprises 87,000 acres of valley land and 137,000 acres of plains on the west side of Sacramento River in Tehama County, from Red Bluff south to the Tehama-Glenn County line. Local drainage from the coast range hills yields a considerable run-off of largely torrential character chiefly through Toms, Elder, Red Bank, and Read creeks. No gagings are available for these streams, but none of them carries summer flow of consequence, Toms Creek being the most productive. A reservoir site of 45,000 acre-feet capacity is said to be at hand on Elder Creek and several others are reported, one of which was noted by the Geological Survey.[1] One is claimed to be located near Newville, to which waters of Toms, Grindstone, and Little Stoney creeks are claimed to be tributary, but no reliable data are at hand to demonstrate its value. In general it may be said that pumping from underground sources for the higher valley lands about Corning and from Sacramento River for the Sacramento River bottoms must be the chief means of bringing water to the area. Eventually, however, it would appear that a high-line canal from Sacramento River above Red Bluff will furnish water to the lands on which its use is justified that are not otherwise supplied; also that whatever storage is found feasible on the torrential creeks mentioned will be utilized and the present small use on those streams thereby increased. As some of the higher plains of the Red Bluff-Corning area are of low agricultural value owing to the outcropping of hardpan and the closeness of cemented strata to the surface,

[1] U. S. Geol. Survey Water Supply and Irrig. Paper No. 86.

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the assumption is reasonable that, although nearer to a water supply than the plains farther south, they will be later watered.

Excepting immediately along Sacramento River and west of that river above Tehama, agricultural production is at present relatively not extensive in this area. All of the valley land and most of the plains was, however, originally devoted to grain growing. Later the higher valley lands and some of the plains were set out to orchards, but as the necessity for irrigating these orchards was not appreciated and proper care was not given to them, many were abandoned and now furnish clear proof that successful farming here depends upon water. At present irrigation is mainly in four sections—along Sacramento River near Tehama, where about 1,000 acres of alfalfa are watered; in Richfield colony, where 1,700 acres are irrigated from two ditches of the Corning Irrigation Company; in the Maywood Colony about Corning, where 172 pumping plants supply 1,367 acres; and in the Richfield lands south of Toms Creek and south and east of Richfield, where water is being developed from wells for approximately 5,000 acres, of which only a small portion were irrigated in 1912. Additional irrigation of small areas is found along Toms and the other creeks. When crops are irrigated in this area their yield is highly satisfactory, and in some cases yields have been found profitable without irrigation. The plantings of orange, lemon, olive, and of almond, peach, prune, fig, and other deciduous trees have proven the adaptability of the uplands of this area to fruit growing, and where additional water is brought in, such cultures are likely to predominate.

ORLAND AREA.

This area lies immediatedly south of the Red Bluff-Corning area extending from the Glenn-Tehama County line to an east and west line 5 miles south of Orland. The area scales to 79,000 acres of valley and 32,300 acres of plains, of which 5,300 acres were reported irrigated in 1911. Of this, 2,600 acres were alfalfa, gardens, and young orchards under the Orland Project, 2,500 acres were sugar beets irrigated by the Sacramento Valley Sugar Company from pumps on Sacramento River and 200 acres, mostly alfalfa, were irrigated by pumping from the overflow of Stoney Creek. This is the only area north of Woodland area that is fed by a substantial west-side stream, the source here being Stoney Creek. North of Stoney Creek the area comprises an undulating valley or semi-plains area of gravelly loam, while south of it the soil is partially similar and partially more sandy, becoming heavier near Sacramento River. West of Orland the better bare rolling plains begin, extending south through the area.

Stoney Creek has been carefully studied for its storage possibilities by the Reclamation Service, and East Park Reservoir, with a capacity of 26,000 acre-feet, has been built. Other sites surveyed by the Reclamation Service are Briscoe site, with a capacity of 14,385 acre-feet, and Mill site, with a capacity of 43,735 acre-feet.[1] Stoney Creek tributary

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to these reservoir sites drains 735 square miles of Coast Range hills through a north and south valley lying about twelve miles east of the Sacramento Valley floor. The discharge recorded at the Geological Survey gauging station west of Fruto shows a mean annual flow from 1901 to 1910 of 581,000 acre-feet.[2] Approximately 80 per cent of the total drainage of Stoney Creek lies above Fruto. With complete utilization of mean spring and early summer flow available for direct diversion without storage, approximately 90,000 acre-feet, there is surface water available on a gross duty of 3 acre-feet per acre for approximately 65,000 acres of land, or on a gross duty of 2 acre-feet per acre for over 90,000 acres. This, however, would require diversion capacity greater than is reasonably likely. As at present constructed, Orland Project of the Reclamation Service covers only 14,000 acres. Central Canal of the Sacramento Valley Irrigation Company passes through the Orland area near its eastern edge and might irrigate the land adjacent to it, and additional land will be watered from the pumping plants of the Sacramento Valley Sugar Company at Hamilton. As, in addition to Stoney Creek and Sacramento River, water-bearing gravels underlie much of the Orland area, with usual lifts of only about 20 feet, it is reasonable to assume a water supply for the entire valley area, and so much of the plains as it is later found feasible to cover from Sacramento River. But very little land in this area is subject to overflow. The crops irrigated are all of those common to Sacramento Valley, from citrus fruits to alfalfa. No extensive citrus planting have been made, but several small orchards show adaptability. Most of the present irrigated holdings in Orland Project are small and not yet far advanced, although water has been supplied for some years to some of the lands in the project through two canals from Stoney Creek that were taken over by the Reclamation Service.

STONEY CREEK AREA.

While not properly part of Sacramento Valley, this area is better described here than elsewhere. It consists of scattering pockets of valley land along Stoney Creek before this creek enters Sacramento Valley. The valley has an approximate length from East Park Reservoir of 35 miles with a maximum width of 7 miles at Elk Creek. According to information furnished by the Reclamation Service, 38 diversions from Stoney Creek above the Orland Project headworks, with a total average discharge of 88 cubic feet per second, irrigated 1,550 acres in 1911, of which approximately 950 acres were near Stoney Ford. The crop irrigated is practically all alfalfa. An additional 700 acres are reported irrigated on the tributaries of Stoney Creek. Owing to the roughness of the valley and opportunities for using the water of Stoney Creek in Sacramento Valley, but little irrigation extension can be expected here. The total area of valley land is roughly estimated at 3,000 acres.

[1]U. S. Reclamation Service, 5th Annual Report, and U. S. Geol. Survey Water Supply and Irrig. Paper No. 86.

[2]U. S. Geol. Survey Water Supply Paper No. 298.

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WILLOWS AREA.

This area includes 186,000 acres of valley and 40,000 acres of plains in Glenn County south of the Orland area and north of the Glenn-Colusa County line, not including the small area in Glenn County east of Sacramento River and west of Butte Creek. The valley land in this area has an even slope except in the southern portion, which is at the head of Colusa basin and very flat. In general, the soil in the southern portion is clayey, varying from adobe to silty clay loam; in the northern portion, it is a gravelly or sandy loam. Alkali occurs south of Willows in the central portion. The plains in the area are bare and rolling as in the Orland area, but in contrast with those in the Orland area, they lie entirely west of the valley lands. The slopes closest to the valley only are now cultivated, and none are irrigated.

The local watershed west of Willows area is 220 square miles in extent, but the run-off from this finds its outlet only in numerous minor streams yielding torrential flow and losing themselves in Colusa Basin, and is therefore only available, where available at all, as underground flow. The available water supply is, therefore, Sacramento River or underground sources, with some surplus from Stoney Creek, part of which is now diverted in spring by Central Canal. Extensive pumping development has not yet occurred, but several plants are operating above the line of the Central Canal, and the underground sources, for both valley and plains, can be considered as sure to yield large supplies. The Sacramento Valley Irrigation Project now covers from 90,000 to 100,000 acres, including their land in Colusa area, with ultimate enlargement likely. Approximately 8,000 acres of this were irrigated by the entire system in 1911 and 13,000 acres in 1912. Of this total, about 6,000 acres were in the Willows area. For the land west of Central Canal, water will eventually be brought from Sacramento River by diversion higher than that of the present system, as at Iron Canyon; or possibly from the larger tributaries of the Sacramento above Iron Canyon, the water in the latter case to be carried by expensive construction along the western edge of the flatter plains and pumped from there to the higher areas. Extension of the Orland Project southward or the utilization by other means of the additional storage capacity on Stoney Creek would also accomplish this. It is believed that the entire Willows area, less the acreage now comparatively valueless on account of alkali, can be assumed as irrigable, and that it will ultimately all be irrigated. The portion of this area that is subject to overflow during high water in Sacramento River at present approximates 21,000 acres but it is assumed that this will eventually be eliminated by adequate dyking.

The irrigated crops now grown in the Willows area comprise all of those common to Sacramento Valley. The irrigation system now in operation is the beginning of large development on the west side. It was a part of this area that Central Irrigation District, organized in 1887 but never in successful operation, was intended to cover, and for

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which Central Canal, now owned by the Sacramento Valley Irrigation Company, was largely constructed. Here the numerous problems common to west-side development under irrigation will be encountered, including diversion and pumping from Sacramento River, protection of lowlands from overflow, drainage and reclamation of the swamp and alkali areas, control of the surface drainage from the west-side foothills, getting water to the west-side plains, and the other problems connected with the sucessful working out of any large irrigation project.

COLUSA AREA.

This area covers the land in Sacramento Valley in Colusa County west of Sacramento River, scaling to 330,000 acres of valley floor and 39,000 acres of plains, and including the main portion of Colusa Basin. The soil is similar to that of the Willows area, with clay types predominating. A large part of the area is in Colusa Basin and, therefore, in need of drainage and flood protection. Approximately 68,000 acres in this area in Davis, Munson, and No. 108 reclamation districts and under private levees about Grimes have already been dyked and reclaimed. The general plan of flood control for Sacramento River proposed by the California Débris Commission includes a drainage canal from Colusa to Yolo Basin, which is intended eventually to relieve most of the remaining land needing drainage. The amount of land irrigated in the Colusa area in 1912 by the Sacramento Valley Irrigation Company approximated 7,000 acres. The acreage watered by this company is being rapidly increased through extension of Central Canal, which already reaches as far south as Cortina Creek. Irrigation adjacent to Sacramento River and east of the valley trough formed by Colusa Basin is effected by pumping from the river or by admitting water to adjacent land through cuts in the levee, and development of this character will continue and, with complete dyking of the river and the augmenting of its supply by storage above, will eventually cover all of the agricultural land present. Colusa Irrigation Company, the Roberts Ditch Company, and the Reese tract, all near Colusa, were reported as together irrigating 875 acres from Sacramento River when the irrigation census was taken in 1910, with 3,450 acres as the total ultimate area these three small enterprises are to cover.

Aside from Sacramento River there is no stream of consequence tributary to Colusa area. The local drainage on the west approximates 300 square miles, but the run-off from this is largely torrential and not susceptible of being controlled for irrigation. West of Maxwell the first planting of citrus orchards on the rolling west-side plains is under way, with the water supply being pumped over 2 miles and lifted 230 feet from Central Canal, about 45 miles below its intake. The land being so planted is typical of the high rolling plains extending from Stoney Creek to Woodland. The expenditure of about $70 per acre for underground pipe distribution to the plantings and the lifting of water 230 feet, which will be increased next year to 300 feet, is indicative of

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the faith being shown by experienced irrigators in the value and irrigability of these high areas. Two hundred and fifty acres of citrus trees are out here and being watered during the present year, with an equal acreage being planted elsewhere in the valley by the same interests, the total contemplated planting being 10,000 acres.

WOODLAND AREA.

This area includes the valley and valley plains in Yolo County, extending both north and south of Cache Creek, and aggregating 400,000 acres of the former and 78,000 acres of the latter. The drainage tributary to the area consists of 180 square miles of local watershed in addition to 1,200 square miles of watershed tributary to Cache Creek, of which 500 square miles are above the outlet of Clear Lake. Putah Creek, whose possibilities for use in irrigation are discusssed under the Solano area, borders Woodland area on the south and could be used for irrigating land in the Woodland area if not used elsewhere. In addition Sacramento River borders the area on the east. The run-off from the drainage of the Woodland area, other than Cache Creek, is torrential and without definite channels of importance, so that it can not be considered to any extent for irrigation purposes. The run-off from the Cache Creek watershed is important and has been measured for some years by the Geological Survey, which has maintained stations both at the outlet of Clear Lake, at Lower Lake, and at Yolo. The mean annual run-off at Lower Lake from 1901 to 1910 was 385,000 acre-feet, the minimum being 189,000 acre-feet and the maximum 729,000 acre-feet.[1] The possible storage that has been considered in this drainage is at Clear Lake and in Little Indian Valley.[2] Storage in Clear Lake has been discussed for many years, but without development, owing to property complications along its shores.[3] The mean area of the lake is about 40,000 acres. It has been estimated that from 100,000 to 200,000 acre-feet can be economically stored in this reservoir, the amount depending on property adjustments along the lake shore. The estimated possible storage in Little Indian Valley, which lies on the North Fork of Cache Creek, is 50,000 acre-feet, although the reservoir as surveyed would have a capacity of 76,500 acre-feet. Other storage is possible, according to investigations by the Geological Survey in connection with their survey of Little Indian Valley in 1900, but due to uncertain water supply or expensive construction this has not been seriously considered thus far. If storage were feasible for the entire flow of Cache Creek and tributaries, sufficient water would be available for a very large area. The mean annual run-off at Yolo, which is situated well into the valley floor and below present diversions, has been found by the Geological Survey measurements from 1903 to

[1] U. S. Geol. Survey Water Supply Paper No. 298.

[2] U. S. Reclamation Service, 5th Annual Report; U. S. Geol. Survey Water Supply and Irrig. Paper No. 45. For general discussion of irrigation and water-right conditions on Cache Creek see U. S. Dept. Agr., Office Expt. Stas. Bul. 100.

[3] Since this was written, new interests that have purchased the Yolo County Consolidated Canal have been purchasing rights along Clear Lake prior to developing the lake for reservoir purposes.

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1910 to be 695,000 acre-feet, the minimum being 250,000 acre-feet and the maximum 1,280,000 acre-feet.[1]

The present reported irrigated area along Cache Creek is 14,570 acres, the supply for most of which is obtained from Cache Creek, the irrigated crops being alfalfa, sugar beets, deciduous and small fruits, and graden truck. Thus far the water supply made available to the area during the summer months has been very limited, owing to the failure on the part of the company controlling the Cache Creek canals to build permanent diversion works. The result has been that irrigation water has sometimes not been available to those under the canals until late in the summer. Within the summer of 1912 the entire irrigation system taking water from this creek has been acquired by new interests who propose to develop the available water supply fully, in connection with power also, farmers under the system having purchased water rights on an acreage basis to the extent of 50,000 acres at the rate of $20 per acre.

That the possibilities for large irrigation development on Cache Creek are great is indicated by the water supply data above cited. The water supply usable directly for irrigation from the creek during the years of even minimum flow is large. If 200,000 acre-feet could be stored in Clear Lake and 50,000 acre-feet in Little Indian Valley, the total area that might be served under a gross duty of 3 acre-feet per acre would exceed 83,000 acres above the present irrigated area. This would not include the extra supply usable by direct diversion during normal years and years of excessive flow, nor the supply available by pumping from underground sources. If only 100,000 acre-feet can be stored in Clear Lake, this increase would be 50,000 acres without considering extra water available in the irrigation season and pumping. If the gross duty could be reduced to 2 acre-feet per acre, the additional irrigable area would exceed 125,000 acres with 200,000 acre-feet stored in Clear Lake, or 75,000 acres with that storage only 100,000 acre-feet. Irrigation by pumping is already beginning to supplement that from canals and will increase considerably in the future. North of Cache Creek the water-bearing gravels appear to occur irregularly, making the supply to be obtained from wells uncertain. In the southern portion of the area the underground supply has been found to be more regular, but thus far no large development by pumping has taken place except directly along the banks of Cache Crek, where some very large pumps have been installed for irrigating sugar beets.

The eastern part of the Woodland area extends into both Colusa and Yolo basins and is therefore subject to overflow. Reclamation of the overflow lands has been carried out in Yolo County in both of these basins, namely in reclamation districts 108 and 787 east of Colusa Basin above Knights Landing, and in Elkhorn and numbers 785, 811, 900, 742, 765, and 307 reclamation districts east of Yolo Basin, some of this, however, being now under way. The main by-pass of the proposed

[1] U. S. Geol. Survey Water Supply Paper No. 298.

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reclamation project of the California Débris Commission traverses the entire portion of Yolo Basin lying in this area, the overflow from all of the basins of the valley being collected into this by-pass between Sacramento and Knights Landing. While approximately 204,000 acres in Woodland area are now subject to permanent or temporary overflow, the non-agricultural area that will be left after completion of the reclamation project, assuming this to approximate the area between the by-pass levees, will be only about 50,000 acres.

Irrigation from Cache Creek began in 1856 when construction was started on the old Moore Ditch, which has been the nucleus of the present canal system on this creek. Little irrigation was practiced, however, prior to 1864. Up to 1881 temporary brush dams were installed each year at the head of Moore Ditch, but in the latter year a more permanent wooden structure was built, this, however, lasting only five years. During this time, in addition to Moore Ditch, the Capay and Adams ditches had been built to cover large areas of grain lands, but these were abandoned as a result of extensive litigation over water rights. By sale and reorganization in 1903, all of the old canals passed into the hands of the Yolo County Consolidated Water Company, but as already indicated, this company did not establish its system on a sufficiently substantial basis to give adequate service. If the new interests that have recently taken over the properties of the Yolo County Consolidated Water Company accomplish maximum development along Cache Creek, agricultural conditions will be very different from those obtaining at present.

CAPAY VALLEY.

This area might properly be classed as part of Woodland area, although it was separated for purposes of investigation because of its isolation. The section included is the narrow valley along Cache Creek from Capay to Rumsey, with a total area of 10,000 acres. Only 160 acres are reported irrigated at present, this being chiefly alfalfa, and receiving most of its water from a small ditch out of Cache Creek near Rumsey. Some citrus fruits are raised in favored localities, although not yet on a commercial scale. The entire area can be supplied with water from Cache Creek either by gravity or pumping from the gravels near the creek bed. At present no extensive pumping is done away from the creek. Underground water is now found between Capay and Guinda at from 15 to 35 feet below the surface with a lift of 15 to 20 feet, these conditions having been noted in domestic wells only. The mean of the rainfall records for Rumsey, Guinda, and Capay shows a normal fall of 22.97 inches, which has been found sufficient for the successful growth of deciduous orchards, to which the upper portion of the valley is now devoted, although here as elsewhere in Sacramento Valley irrigation would be very advantageous in the dry summer months, especially in years of less than normal precipitation. It is believed that ultimately this entire valley will be watered, and the assumption seems reasonable that this could be accomplished without

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any large diminution of the water supply available to the Woodland area below.

SOLANO AREA.

This area extends from Putah Creek on the north and Sacramento River on the east to swamps and hills on the south and west, and contains 157,000 acres of valley agricultural land, exclusive of Sacramento River islands. In general, the area covered is the northeast part of Solano County, around the towns of Dixon and Elmira. The area reported irrigated in 1910 was 2,527 acres, the irrigated crops being a few tracts of deciduous fruits, alfalfa, and berries, wheat and barley being dry farmed. The local drainage tributary to the area is small and of low run-off yield, but Putah Creek, draining 800 square miles of rolling hills and higher mountains, is tributary to the north. A gaging station has been maintained on this stream at Winters by the Geological Survey since 1905 and the mean of five years' record shows an annual run-off of 515,000 acre-feet, the minimum year having 199,000 acre-feet.[1] In connection with their study of the proposed Sacramento Valley Irrigation Project, the Reclamation Service reported two available reservoir sites on this stream, at Guenoc and at Monticello.[2] The former of these sites has a surveyed capacity of 188,000 acre-feet and an estimated available water supply of 80,000 acre-feet. The Monticello site is near the lower portion of the stream and has a surveyed capacity of 130,000 acre-feet and can be filled annually. Putah Creek has a small summer flow, the discharge in the irrigation season in mean years being 52,000 acre-feet and in the minimum year only 14,300 acre-feet. The full run-off in minimum years could be utilized by the construction of the two reservoirs mentioned, and by using the excess capacity at Guenoc site the years could be partially equalized, giving more than 80,000 acre-feet annually available from the latter source. Discharge records kept by the Geological Survey at this reservoir for 1904–06 showed an excessive annual flow, but it has been estimated by the Reclamation Service that 80,000 acre-feet are annually available. With 130,000 acre-feet which could be stored in Monticello reservoir, 80,000 acre-feet from the Guenoc site, and the 14,300 acre-feet summer flow available in the minimum year of which records are available, the total surface water supply open to this area approximates 264,000 acre-feet, or sufficient for 88,000 acres under a gross duty of 3 acre-feet per acre, or 132,000 acres under a gross duty of 2 acre-feet. At present irrigation development is mainly by pumping from wells near Dixon and a few pumping plants from sumps on Putah Creek. The extent of underground water in this area has not been determined, but at present development is rapid and the supply is apparently sufficient for considerable increase. The present wells are from 90 to 110 feet deep, the water rising to within 15 or 20 feet of the surface. It seems apparent, therefore, that with full utili-

[1] U. S. Geol. Survey Water Supply Paper No. 298.
[2] U. S. Reclamation Service, 5th Annual Report.

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zation of the present storage facilities and full development of underground water, all of the 157,000 acres of valley agricultural land in this area should be considered susceptible of irrigation. Approximately 51,000 acres are within the zone of permanent or temporary overflow, but the reclamation project that has been proposed will, using the same assumptions regarding the non-agricultural area that will remain after reclamation that have been used heretofore, be reduced to about 15,000 acres. Present reclamation in this area is not large and is mainly in Tyer and Sutter islands, between Rio Vista and Courtland.

VACA VALLEY.

This area comprises all of the well known Vaca Valley, of which Vacaville is the principal center. It is a small, narrow area, chiefly devoted to deciduous fruits, with alfalfa an incidental crop only. About 50 acres are reported irrigated. A 28-year rainfall record at Vacaville shows a normal fall of 27.84 inches. Irrigation is at present locally considered unnecessary. Eventually, however, it would seem as if the limited water supply available would be utilized. The watershed covers 35 square miles and would undoubtedly supply all the water needed for irrigation on the 7,000 acres in the valley proper if the storage were available for its conservation. There are no tributary streams of consequence, and for present purposes at least the only available water supply must be from pumping.

SUISUN AREA.

This area includes the valley agricultural land in southwest Solano County and extends from Laurel Creek on the east to marsh lands on the south and hills on the north and west, containing in all 30,000 acres. This is an evenly-sloping plain of heavy clayey soil. The principal crops now grown are deciduous fruits, with 278 acres reported irrigated in 1909. The area above the valley land is to some extent dry-farmed to grain. No streams of importance enter the area, the local water supply being derived from 100 square miles of bare rolling hills, giving a torrential run-off of generally small volume. The underground water has not been tested for quantity, but unless it is found sufficient it would seem that if irrigation is resorted to here the principal water supply will need to be brought from other than local sources, such as storage water from Putah Creek in the north. The present small area irrigated is mainly from wells, as irrigation for the fruit now raised is considered locally to be unnecessary, the annual rainfall averaging over 20 inches. Extensive irrigation is hardly to be expected here, yet the present small irrigated area will be increased.

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EAST SIDE OF SACRAMENTO VALLEY.

RED BLUFF-VINA AREA.

This comprises 34,500 acres of rich valley land and 29,000 acres of plains east of Sacramento River from Red Bluff south to the Tehama-Butte County line. This section has been the location of several of the famous ranches of Sacramento Valley, including the Cone Ranch near Red Bluff, the Los Molinos Ranch opposite Tehama, and the Stanford Ranch at Vina. These large holdings have retarded extensive irrigation, but subdivision and development of small irrigated farms have at last started, and, in 1912, 9,600 acres are being watered. Of this, 260 acres are reported under the flume of the Diamond Match Company, and near Sacramento River southeast of Red Bluff 840 acres are on the Cone Ranch, 5,500 acres in the subdivided Los Molinos holdings, and 3,000 acres on the Stanford Ranch at Vina. In this area are three important perennial creeks, viz., Antelope, Mill, and Deer creeks, and an additional water supply is available from underground sources and from Sacramento River. No gagings are available for the east-side streams except Mill Creek, but eleven measurements made by the Geological Survey on that stream at the Los Molinos dam from August to December, 1909, showed a mean flow of 215 cubic feet per second, 207 cubic feet per second being the minimum. All of this creek is claimed for the Los Molinos holdings. The tributary drainage of Deer Creek is 192 square miles and the entire flow is claimed by the Stanford Ranch. Antelope Creek and tributaries are wholly claimed by the town of Red Bluff and the Cone Ranch. Counting Sacramento River, the water supply is more than ample for this entire area, but the use of the Sacramento here, other than by pumping, would involve the proposed diversion at Iron Cañon. The main crops now grown are the usual grains and irrigated alfalfa, with a large acreage of vines on the Stanford Ranch. In the Los Molinos section and elsewhere after subdivision and the provision of an irrigation supply, alfalfa, deciduous fruits, and the miscellaneous crops common to diversified farming in California will be the ones grown and watered. The portion of this area nearest to Sacramento River is thickly dotted with large oaks and thus exhibits a landscape of natural beauty. The productiveness of the soil here, as well as along almost the entire stretch of Sacramento River bottoms from Red Bluff south to the swamp lands, and a normal annual rainfall varying from 23.39 inches at Chico to 26.11 inches at Red Bluff, have resulted in profitable grain farming and considerable successful deciduous fruit growing without irrigation. The limits of dry farming, however, even in this area, or at least the greatly increased crops and the larger opportunity for diversifying production under irrigation, have established the fact that little material advancement over past conditions is possible without artificial watering. How striking this fact is is amply proven by the contrast observed in the summer of 1912 between the vast unirrigated grain

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fields of the Cone Ranch, which are as they have been for over fift years, and the subdivided areas of the Los Molinos holdings immed ately adjoining on the south, where twenty new and mostly mode small farm houses were noted within what appeared to be a sing square mile.

CHICO AREA.

This covers 138,000 acres of valley and 15,200 acres of valley plai in Butte County, south of the Tehama County line, east of Sacramen River, north of Butte-Glenn County line, and west of Butte Creek a the lava foothills north of Chico. The present irrigated area here reported as only 800 acres, this being mostly covered from pum along the streams, chiefly Chico Creek and Sacramento River. T irrigated crops are alfalfa, a few orchards, and hops, the latter bottom lands northwest of Chico. A considerable portion of this ar is subject to overflow from Sacramento River and its tributary creek so that drainage is more of a problem on the lower lands than irrig tion. According to best available data, 38,000 acres east of Sacramen River and mostly south of Chico are within the boundaries of the lan subject to temporary overflow. A very large proportion of the la of this area is still in the large holdings of the early California farmi days. Numerous local streams are tributary to the Chico area, b the main water supply for irrigation must come from undergrou sources, Sacramento River, and Chico and Butte creeks. The two latt streams drain 230 square miles of the lower Sierra and furnish a co siderable run-off, which with storage could be made to supply a su stantial part of the agricultural land in the area. No gagings, ho ever, are available for these streams, nor is information at hand as possible storage. Private water claims on them would complica their use in irrigation outside of on a few large holdings to which th have been attached. Also, along with other land in Sacramento Valle on both east and west sides, this area could be covered by high-li diversion from the Sacramento. Bored wells, 40 to 60 feet deep, wi lifts of from 20 to 30 feet, located in different parts of the area, a furnishing some irrigation supply. A 39-year rainfall record at Chi shows a normal annual precipitation of 23.39 inches. The richne of the soil, the moist conditions of the lower lands, and the adequa of the annual rainfall for general farming, here as in the Red Blu Vina area has led to the popular conclusion that irrigation would n be beneficial, but recent irrigation development on the Los Molin lands to the north, and the development of the past decade on t Feather River lands to the south, furnish examples of the benefits irrigation whose force must be felt at Chico. While the entire vall acreage within this area will never be extensively irrigated because is in no sense arid, time will demonstrate that the productions on t higher valley lands will be greatly increased with summer water, a when or before these are covered water is sure to be brought to such the plains areas above as are fertile and arable but which are now us

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only for grazing. For these the only available extensive supply is Sacramento River.

GLENN-COLUSA EAST-SIDE AREA.

Both Glenn and Colusa counties extend east of Sacramento River to Butte Creek and form a relative narrow area of 82,500 acres of which a considerable portion is subject to overflow. No irrigation is reported for this area. Whatever water supply is needed for irrigation can readily be obtained from underground or from Sacramento River. Throughout the north and south distance a strip from 1 to 4 miles wide consists of marshes, ending in the southern end opposite Colusa in Butte Sink. The higher lands in this area are those bordering Sacramento River and Butte Creek. Of the cultivable area, 21,000 acres are in the large Moulton Reclamation District. The proposed by-pass through Butte Basin bisects the portion of the area in Colusa County, leading thence southwest of Marysville Buttes into Sutter Basin. With Sacramento River, Butte Creek, the streams about Chico, the proposed by-pass adequately leveed, and the lowlands drained, the agricultural area in these eastern portions of Glenn and Colusa counties would approximate 70,000 acres, all irrigable to the extent irrigation is necessary.

FEATHER RIVER AREA.

This is one of the most important irrigation areas in northern California and one of those selected for detailed study of use of water during 1912. Not only is Feather River, which feeds this area, one of the largest of the Sacramento River tributaries, with extensive areas of foothills, plains, and valley subject to its water supply, but within its zone irrigation has developed farther than in any other Sacramento Valley area of equal acreage. Here are combined the complexities of flood-protection, drainage, irrigation, mining, and hydroelectric power in such a way as to typify the larger development problems of Sacramento Valley.

The valley and plains in the Feather River area approximate, respectively, 266,000 and 86,000 acres. Of this, 236,000 acres of valley and 37,000 acres of plains are between Feather River and Butte Creek, and 30,000 acres of valley and 49,000 acres of plains east of Feather River. The portions of the entire area that are subect to temporary overflow, and that are therefore in need of further protection, cover approximately 52,000 acres along Butte Creek on the west and approximately 12,500 acres east of Feather River between Honcut Creek and Marysville, not counting 3,500 acres east of Feather River included below in the Yuba area.

It is stated above that Feather River is one of the larger Sacramento River tributaries. Discharge records kept at Oroville from 1902 to 1910 by the Geological Survey show a mean annual run-off at that point of 6,020,000 acre-feet, the minimum year giving 3,490,000 acre-feet and the maximum 9,340,000 acre-feet.[1] An examination of reser-

[1] U. S. Geol. Survey Water Supply Paper No. 298.

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voir sites was made by the Reclamation Service,[1] and several having total capacity of 1,879,209 acre-feet were found, for which the annua available water supply was estimated as 1,649,385 acre-feet. Thi storage includes 22 reservoirs with a total capacity of 87,000 acre-feet which were built for mining purposes, the Big Meadows site on th North Fork of Feather River, controlled now by the Great Wester Power Company, and having a surveyed capacity of 780,384 acre-feet and the Valley site on Indian Creek, where it was estimated 500,00 acre-feet could be stored. With a recourse to stored water in Augus and September only, and utilization of the quantity directly availabl in mean years during the irrigation season, April to September, tha could be diverted by a total canal capacity of 2,500 cubic feet pe second, a total of 915,000 acre-feet would be available or sufficient fo 305,000 acres on a gross duty of 3 acre-feet, and for 467,500 acres on gross duty of 2 acre-feet.[3] With a total canal capacity of 5,000 cubi feet per second, and recourse in mean years to storage in July, Augus and September, 610,000 acres could be irrigated on a gross duty o 3 acre-feet per acre, and still leave a surplus of more than one millio acre-feet of water in the various reservoirs, provided they were full developed.

While Feather River carries water in excess of the needs of the lan directly tributary to it, so that a supply is available for the sectio northwest of Butte Creek, if taking it there is found economical, no all of the land to be irrigated in this area will receive its supply fro the Feather. Honcut Creek and tributaries, entering the Feather belo Oroville, already irrigate a small acreage, and it is possible that storag will be found on them to hold some of the drainage from the tributar watershed. Filings have been made for storage here, but no exact dat are at hand as to the presence of reservoir sites, and it is not likel that any of importance are at hand. In the lower portions of the are underground sources are sure to be increasingly drawn on as Feathe River power is more fully developed and made available at lower rat for pumpings. The extent of economical use possible from the Feathe east of its channel is problematical, the main river branching abo Oroville, and its Middle and North forks being difficult of access fo the higher lands there, except by pumping. At present, all of the lo water flow in South Fork is being utilized on these east-side land While some storage is probable here, its extent and economical valu are not known. There is little likelihood that enough is available he or on the tributaries of Honcut Creek to cover all of the irrigable lan on the east side; consequently, if the entire 79,000 acres of valley an plains is to be irrigated, part of the supply must be carried entirely b gravity or be pumped from the Feather below its forks and then le by gravity to the necessary points of distribution. A part also is likel

[1]U. S. Reclamation Service, 4th and 5th Annual Reports.

[2]It is proposed by the Great Western Power Company, who now control B Meadows, to construct their dam to a height of 110 feet, which is said will give capacity of 1,250,000 acre-feet, and cover an area of 40 square miles.

[3]This would assume filling the reservoirs outside of August and September.

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to be watered by gravity diversion near the head of Butte County Canal. A similar situation exists west of the main Feather. Development now under way will utilize all of the low flow at Oroville and increases above the existing projects must involve both storage and pumping below and probably also above Oroville. That this will ultimately be resorted to both here and on the east side there can be little doubt. The Feather River Canal Company already contemplates two lifts of 20 feet each from its main canal to cover an estimated 17,500 acres. The available hydroelectric power on the Feather and its branches is enormous and is sure to be available, owing to the relatively short transmission necessary, at rates that will justify such use of it. If present development in progress on Big Meadows Reservoir is completed, the low flow of the river above Oroville will be increased, according to the plans of the Great Western Power Company, to 2,500 cubic feet per second. The water thus made available can only be utilized either by pumping, as suggested, or high-line construction of all-gravity canals that is likely to be so much more expensive than part pumping and part gravity diversion as to make the latter the more economical. The announced plans of the great Western Power Company include the use of the water impounded in Big Meadows Reservoir for irrigating 200,000 acres of land below Tehama, but it is not known that plans for such development are beyond the formative stage.

Present irrigation in the Feather River area is chiefly under Butte County Canal, which in 1912 watered 14,000 acres, mostly in alfalfa and deciduous fruits, in the valley west of Feather River; under the reservoir and pipe-distribution systems of the Oroville Water Company and the Oro Water, Light, and Power Company, which in 1912 delivered water to 810 acres, principally in olives and citrus fruits, in the vicinity of Thermalito; and under the system of the Palermo Land and Water Company, which in 1912 irrigated 1,880 acres, mostly in oranges, olives, and peaches, in the Palermo Colony. An additional scattering area of about 500 acres is irrigated from Honcut Creek, by pumping from Feather River, and from wells, making the total for the area 17,190 acres. The Butte County Canal is intended ultimately to cover 200,000 acres. An additional large canal is now being constructed by Feather River Canal Company from Feather River about Butte County Canal, this being intended to cover probably 30,000 acres by gravity and an additional area by pumping from the canal to the plains near Tres Vias, as already indicated.

SUTTER BASIN AREA.

This comprises 158,000 acres of valley south of Marysville Buttes and Marysville and between the Feather and Sacramento rivers, in Sutter County, about 16,000 acres of which are in Reclamation District No. 70, 46,000 acres in Reclamation District No. 1, and 6,300 acres under private reclamation. A considerable portion of the area is occupied by Sutter Basin, 31,000 acres of which are classified on the latest topographic map as marsh, and 116,000 acres are subject to overflow.

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Bordering Sacramento River, the land is 12 to 15 feet higher tha in the trough of Sutter Basin, as it is along the Feather River on th west. The Sutter Basin by-pass proposed by the California Débri Commission traverses the entire length of this area, gathering th overflow from Butte Basin west of Marysville Buttes and deliverin it to the Sacramento at the mouth of the Feather. While the highe portions of this area may reasonably be classed as irrigable, it is plai that throughout the area the question of drainage is more serious tha that of irrigation. There is apparently no necessity for bringin gravity water to this section, and the ultimate desire will probably b to entirely confine Feather River within its channel—it is now leveed o its west bank—and to develop by pumping all the water that is neces sary for irrigation. Only 218 acres are reported irrigated here now When the reclamation proposed by the California Débris Commission i completed, the agricultural area here will approximate 130,000 acres.

YUBA AREA.

This covers the land north of Marysville tributary to Yuba Rive and the area between the Yuba and the Bear east of the Feathe the valley land approximating 113,000 acres and the plains 14,50 acres. Approximately 36,000 acres are subect to overflow, part o which has been included in reclamation districts 784 on the Feathe and 817 north of the Bear at Wheatland. The entire area is in Yub County, and the crops grown are chiefly grains, with some alfalf along the river bottoms and a considerable area of hops north of Bea River near Wheatland. Much the plains area is now in pasture. Ou side of 15,000 to 20,000 acres of hydraulic mining debris between th levees near Marysville, the soils of the area are similar to those o other east-side areas already discussed, varying from sandy and silt loams and clays near the Feather to the red gravelly uplands o the plains. The water supply of the area is Yuba and Bear rivers an underground sources. Discharge records of the United States Ge logical Survey from 1903 to 1910 show a mean annual flow in th Yuba at Smartsville of 3,220,000 acre-feet, the minimum year givin 1,590,000 acre-feet and the maximum 4,560,000 acre-feet.[1] Storage fo power for mining was constructed prior to 1900 to the extent of 112,00 acre-feet.[2] and additional storage has been and is now being built. Th Oregon House Valley site on North Fork of Yuba River is reporte by the United States Reclamation Service to have a capacity of 90,82 acre-feet, with its full capacity available above it.[3] Lake Spauldin reservoir of the Pacific Gas and Electric Company on South Fork Yuba is now being increased to hold 91,800 acre feet, which will carried to the Bear in the course of its use in generating power, indicated in the discussion of the northern Sierra foothills. It is n possible to figure now on the ultimate place of use of this water or wh

[1] U. S. Geol. Survey Water Supply Paper No. 298.
[2] U. S. Dept. Agr., Office Expt. Stas. Bul. 100.
[3] U. S. Reclamation Service, 5th Annual Report.

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proportion will be used in the valley and what proportion in the Placer County fruit districts above, but it is evident that the storage now or likely to be available on the Yuba, and the amount of water carried by that stream during the irrigation season, insure eventually a complete supply to the lands of the area needing irrigation and that will not be supplied by pumping and by the minor streams. Carrying water from the Yuba to the Bear is also likely to result eventually in using some of this supply in the area between the Bear and the American.

Present irrigation in this area covers 3,000 acres under Hallwood Ditch, 640 acres under Stall Ditch, both from the Yuba north of Marysville; and, according to the irrigation census, 546 acres scattering. Hallwood and Stall Ditches have a common diversion in the Yuba at Daguerre Point weir and are together intended ultimately to water 10,000 acres.

SACRAMENTO-LINCOLN AREA.

This comprises 246,000 acres of valley and 94,000 acres of plains south of Bear River, east of Feather and Sacramento rivers, and north of American River, in Sutter, Placer, and Sacramento counties. A feature of this area is American Basin, which extends along the east bank of Sacramento River directly north of Sacramento. The reclamation of this basin and of a strip of land north of it along Feather River and along the south bank of the Bear, aggregating 85,000 acres in reclamation districts Nos. 1000 and 1001, is in progress by the Natomas Consolidated Company. This company proposes, after reclamation is effected, to provide such water as is necessary for irrigation from Feather, American, and Sacramento rivers and to subdivide the land into small farms. The reclamation, and necessary irrigation, of the entire western part of this area being thus provided for by interests sufficiently strong to complete them, the concern of the public is chiefly in the eastern part of the area from American River west of Fair Oaks Colony northward through Antelope, Roseville, Lincoln and Sheridan to Bear River. The land in this section aggregates 215,000 acres, largely plains, that portion generally east of the Southern Pacific Railroad being to a considerable extent of the hog-wallow type and used mainly for pasture. Outside of pumping from underground sources and from Feather and Sacramento rivers for the Natomas lands, if this is resorted to, as seems likely, the water supply tributary to the Sacramento-Lincoln area must mainly be that of the Bear and American rivers. Gaging stations have been maintained by the Geological Survey since 1904 on both of these streams, on the former 8 miles above Wheatland and on the latter at Fair Oaks.[1] The mean annual discharge of the Bear from 1904 to 1910 was 416,000 acre-feet, the minimum being 188,000 acre-feet and the maximum 726,000 acre-feet. For the

[1] U. S. Geol. Survey Water Supply Paper No. 298.

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same period the mean discharge of the American was 3,660,000 acre-feet, with a minimum of 1,450,000 acre-feet and a maximum of 5,710,000 acre-feet. No storage has been found on the Bear by the Geological Survey, but it is understood that private interests have located some sites which they propose to develop in connection with power. Also, as indicated in treating of the Yuba area, water stored on the Yuba is to be turned into the channel of the Bear. If this is done so as to increase the low-water flow of the latter, some water may thus be made available for use south of it on the lands of this area. One enterprise to accomplish this has been projected. Unless water stored on either the Yuba or Bear is available, but little further diversion for irrigation from the Bear can occur because the summer flow of that stream is small, and already the subject of litigation in connection with its use on hop fields about Wheatland.

Considering this area with reference to a possible water supply from the American, conditions are equally problematical, although the American, like the Bear, is capable of irrigating a very large area with storage. Water is now being brought from North Fork of American River to 4,000 acres in the Orangevale and Fair Oaks colonies in the lower Sierra foothills, and those controlling this supply claim ability to cover land in this area as far north and west as Antelope. The North Fork, however, carries only a small summer flow, and extension of use beyond the lands already covered will involve reservoiring. To bring water from the main American will require either diversion some distance above Folsom, in which case lower power interests would have to be considered, or diversion below Folsom by pumping. While either or both of these plans may later be feasible, no data are at hand to indicate which will prove the more economical. The large amount of power that will be developed on the American, however, insures that extra-expensive all-gravity diversion is not likely. Although better sustained than the Bear, American River likewise carries a low summer flow only, the 1904-1910 mean for September being only 330 cubic feet per second. One reservoir site with a capacity of 65,952 acre-feet has been reported by the Reclamation Service at Greenwood, and the Geological Survey has said[1] that storage is feasible on Middle and South forks for power purposes. Full data, however, are lacking for a satisfactory estimate of possibilities on this stream. If sufficient storage can be found for the irrigation of 250,000 acres on a gross duty of 3 acre-feet per acre, only about one half of the total run-off in minimum year would be required. As the land south of American River is probably more easy to cover from that stream than the land north of it, the assumption seems warranted that a larger development from this stream will come there than in the Sacramento-Lincoln area. If complete study shows that but little water will be available from the Bear in summer through storage on that stream or on the Yuba, and if the course

[1] U. S. Geol. Survey Water Supply Paper No. 271.

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of development results in American River being mainly devoted to land south of it, irrigation in the Sacramento-Lincoln area must come largely through all-pump supplies. Some underground water is sure to be developed, as it has been already in scattered localities, and if the higher-priced orchard fruits can be produced successfully on the upper valley and plains lands east of the Natomas reclamation, pumping water eastward from the Feather and the Sacramento would not seem entirely beyond economical procedure for the future. At present, subdivisions are being sold east of Sacramento, as on the Haggin Grant, without a surface water supply, and efforts to obtain underground irrigation water are in some cases successful. The crops now grown in this area are chiefly grains, occasional patches of alfalfa on the moister bottoms, and numerous orchards about Roseville. The irrigated area is reported as only 225 acres. The soils are as a whole typical of Sacramento Valley, varying from deep alluvium near the rivers to cemented gravel in the plains, with much of the loam underlaid with tough hardpan.

SACRAMENTO-GALT AREA.

This covers the section of Sacramento Valley south of American River and east of the Sacramento in Sacramento County, exclusive of the Sacramento River islands. Of a total of 344,000 acres, 236,000 acres are valley proper and 108,000 acres are plains. Of the valley land, 70,000 acres nearest Sacramento, Cosumnes, and Mokelumne rivers are within the area subject to temporary or permanent overflow. A total of approximately 26,000 acres along the east bank of Sacramento River is under full or partial reclamation, or in process of reclamation, in reclamation districts 673, 774, 745, 813, 755, 551, and 554, named in order down the river from Sacramento, and in district 1002, north of Mokelumne River. Another small reclamation district lies in the bend of American River immediately north of Sacramento River. Considering both proven underground and surface sources, the Sacramento-Galt area is one of the best watered sections of Sacramento Valley. Of 1,192 pumping plants reported for Sacramento County by the 1909 irrigation census, nearly all are within the area south of American River, the usual pumping lifts averaging 24 feet, and the number per square mile averaging over 10 on many sections. The flow of American River has already been treated with the area last above mentioned, the mean annual run-off at Fair Oaks having been shown to reach over three and one half million acre-feet. Although the mean summer flow of this river for September is only 330 cubic feet per second, some storage is quite sure to be found available. Cosumnes River, with a mean annual flow from 1907 to 1910 at Michigan Bar of 404,000 acre-feet, traverses the southern part of the area.[1] Comparison of the flow of the Cosumnes during this

[1] U. S. Geol. Survey Water Supply Paper No. 298.

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period with the flow of the Mokelumne for which a longer record is available, would seem to indicate that the mean for 1907-10 was about 15 per cent below that for the period 1904-10. For the period for which a Cosumnes River record is available, the discharge during the maximum year was 656,000 acre-feet and during the minimum year 151,000 acre-feet. Owing to the relatively low altitude of its basin, the summer flow of this stream is not well sustained, the mean discharge during August and September being less than 10 cubic feet per second at the gaging station of the Geological Survey. Therefore the use of this stream for irrigation in other than spring and early summer months depends on the amount of storage that can be developed. In addition to several smaller creeks from the east, a third stream available to this area is Dry Creek, forming part of its southern boundary. Discharge records kept on this stream by the California State Engineering Department from 1878 to 1884[1] showed a mean annual run-off of 172,000 acre-feet, but as this stream is generally dry from July to November, as indicated by the records quoted, its irrigation value also depends upon storage.

Present irrigation development in the Sacramento-Galt area, in addition to that by pumping, is under the systems of the Natomas Consolidated Company, near Folsom and Natoma, and of the Cosumnes Irrigation Company, which was irrigating 300 acres on Cosumnes River bottoms when the irrigation census of 1909 was taken. Irrigation by the Natomas Consolidated Company is through extensions of the old Natomas mining ditch and aggregated 1,400 acres in scattered patches in 1912, irrigation under this ditch being incidental to gold dredging in the American River bottoms. This company, however, has a project involving the watering of 30,000 acres south of American River, the supply for which is to be furnished (1) by the present Natomas Ditch, (2) by a pumping plant at Alder Creek now in course of construction and designed to water 8,000 acres, and (3) by the construction of a reservoir on Deer Creek, a tributary of Cosumnes River, said to be capable of holding a maximum of 35,000 acre-feet. The irrigation by pumping in this area, as already indicated, is of first importance, as it is likely to be for much of the area in the future. Of 11,300 acres irrigated here by that means in 1909, some received its water from streams, including the Sacramento, but most of it was supplied from wells, the motive power in many cases being gasoline engines and windmills. During the past year a power line has been extended into the Cosumnes River bottoms, and the acreage being irrigated by pumping has rapidly increased. With other lines, power is or will be available to the entire area.

Considering the ample water supply available to this area, the entire acreage of agricultural land within it may reasonably be considered as irrigable, with the lower lands most likely to be watered by pumping

[1]Physical Data and Statistics of California, Wm. Ham. Hall, 1886.

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and the higher lands by gravity from American River. The present crops are mainly grains, alfalfa, hops, orchards, vineyards, and gardens, with the irrigated holdings usually small.

LOWER SACRAMENTO RIVER ISLANDS.

These include the principal named island areas south from Merritt Island along Sacramento River and the north and west banks of North Fork of Mokelumne and San Joaquin rivers. These are Merritt and Ryer islands, in Solano County, and Sutter, Grand, Andrus, Tyler, Brannan, Twitchell, and Sherman islands, in Sacramento County. These are all reclaimed delta lands of high fertility, devoted mainly to deciduous fruits, grain, celery, asparagus, beans, onions, potatoes, and alfalfa, all of which, excepting grain, are generally irrigated. According to the 1909 irrigation census, 28,272 acres were receiving irrigation water in that year, the means of application being siphons or pumps from the adjacent sloughs or rivers, the operation also involving drainage by pumps or gravity following irrigations or during high water. The total area of land in this island area scales 72,000 acres.

SUMMARY.

The foregoing discussion of the irrigation resources of Sacramento Valley has been written with the object of indicating in more detail than would have been possible under only general treatment both the present extent of irrigation and something of the trend and possibilities of future development. The extent and general soil and topographic conditions of each of the 22 more or less arbitrarily segregated unit areas have been described, and an effort has been made to present such study of the water supply available to each as, first, would show those interested and not otherwise in possession of the facts what may reasonably be expected in water-crop for each area, and second, would furnish a basis for estimating future growth under irrigation. To perform this last-named task can involve but little more than summarizing estimates based on more costly and more exhaustive surveys made by others in the past, with the advantage to our estimates of the additional investigations of ourselves and others during the past few years.

The tabular summary that preceded the discussion of the unit areas carried a total of 2,659,000 acres of valley and a total of 790,000 acres of plains agricultural land, of which only 123,500 acres are reported irrigated by the irrigation census taken in 1910 and revised for all of the larger and important areas to the season of 1912, inclusive. The grand total of the agricultural areas entered in that summary, viz., 3,449,000 acres, is very much larger than any total heretofore ventured for Sacramento Valley, because there have been included more than three-quarters of a million acres of what are herein classified as plains that have not generally been included as part of this valley. This total figure is, however, offered as what very careful consideration seems to warrant calling the Sacramento Valley area topographically suited to receive water. It is also believed that it is reasonable to consider that

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water is economically available for such an area to the extent that it is locally at hand or within reach of canals of no greater length than already have been officially projected and approved for this valley. The prediction is not ventured that all of that great area will some day be irrigated. One million acres, roughly, are within the upper line of permanent or temporary overflow, with 800,000 acres naturally covered by every considerable flood, but of which upwards of 300,000 acres are already more or less securely protected by dykes. To dispose of the high floods of Sacramento Valley will involve the wasting between levees along streams or by-passes, so far as can be estimated from available data regarding reclamation plans thus far matured, of some 250,000 acres. Of the remaining overflow land, much is likely never to be irrigated even if levees and drainage successfully reclaim it, unless such land becomes devoted to that highly intensive cultivation common to the older countries where irrigation and fertilization are the basis of agriculture even in the wet lowlands. Even assuming that water is at hand for all of the plains and for the valley floor above the lowlands, a reasonable reduction for roads, towns, and other uncultivated patches would, together with the elimination of the waste lands between the levees, reduce the area to be irrigated to 2,500,000 acres. But it is not likely that either all of the remaining plains or all of the remaining valley floor will artificially be supplied with water, because the certain course of independent and uneconomical development is quite sure not to bring about complete utilization. Nor will all of the plains prove profitable to irrigate with water carried long distances or pumped against high lifts. To attempt to estimate how much less than 2,500,000 acres will eventually be under water does not seem profitable, but it would seem that that area can be considered irrigable in the sense that water is at hand for it and most of it is fit for irrigation.

The first pages of the discussion presented known available data regarding total water supply and storage possibilities. The total mean annual flow of Sacramento River at Red Bluff, which is above Stoney, Cache, and Putah creeks on the west side, and above Antelope, Mill, and Deer creeks, and Feather, Yuba, Bear, and American rivers on the east side, was shown to be 10,400,000 acre-feet. The best estimate available for the mean annual discharge at Collinsville, at the river mouth, is 26,000,000 acre-feet, with a mean low flow at the same point of 7,000 to 8,000 cubic feet per second and a minimum of about 5,500 cubic feet per second. Assuming 7,000 cubic feet per second as necessary for the maintenance of navigation, and that navigation is a proper use even if less economical than irrigation, and assuming further an annual use of 4 acre-feet per acre for each acre now irrigated in Sacramento Valley, approximately 46 per cent of the mean flow past Red Bluff, or 4,800,000 acre-feet of water, now annually go to waste. Counting only Big Valley and Iron Cañon reservoir sites, above Red Bluff, to the extent that water is probably annually at hand to fill them, 1,226,900 acre-feet of this water now wasted might be saved with con-

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struction of that storage. Reducing the total mean flow at Collinsville by an amount necessary to supply the excessive quantity of 4 acre-feet per acre annually to each acre now irrigated and a constant flow for navigation of 7,000 cubic feet per second, the present annual waste, outside of excessive use, becomes 20,400,000 acre-feet, which could be reduced to about 17,000,000 acre-feet by the construction of all of the storage considered feasible in the reported studies of the Reclamation Service covering irrigation in Sacramento Valley. By the irrigation of 2,500,000 of the 3,449,000 acres found topographically susceptible to irrigation and the annual use thereon of 3 acre-feet per acre, the mean annual flow of the river that would still be wasted, not considering use for power or for irrigation on the irrigable areas of the Sacramento River drainage outside of Sacramento Valley, would considerably exceed the present mean flow into the valley at Red Bluff. The flow at Red Bluff in 1907–08, however, which is the minimum year of record, was only about 74 per cent of the mean.

SUMMARY FOR NORTHERN CALIFORNIA.

In the introductory pages of this report a tabular summary was inserted showing the acreages of valley, plains, and foothill agricultural lands in northern California of importance from the standpoint of irrigation, together with the acreages irrigated. These areas were arranged according to six irrigation divisions or zones, segregated as to similarity of irrigation and other agricultural conditions rather than strictly according to county or hydrographic lines. The summary showed 4,622,000 acres of valley, 790,000 acres of plains, and 789,000 acres of Sierra foothill agricultural land topographically irrigable within zones of water supply for irrigation. Of this, 483,700 acres was reported irrigated, with 161,850 acres of this in the northeastern plateaus and valleys of Modoc and Lassen counties, 123,800 acres in Sacramento Valley, 99,910 acres in the northcentral mountain valleys of Siskiyou, Trinity, and Shasta counties, 50,600 acres in the Feather River Valleys, 45,250 acres in the Sierra foothills, and 2,290 acres in the northern coastal counties.

With the results of no complete studies of underground waters at hand and gagings lacking for some of the important streams and for nearly all of the smaller ones, it is not feasible to state definitely the quantity of water available for irrigation in northern California. But it can be given in general terms on the basis of the water supply records of the Geological Survey and data as to irrigable land and use given in this report.

Northern coastal counties.—In this division, where it is estimated that not over 100,000 acres will ever be irrigated, although one half million acres of valley agricultural land were found, the water supply is largest where the agricultural areas are smallest and the need for

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irrigation is least. For instance, Klamath River, which passes for a number of miles through northern Humboldt County, carries a mean annual flow at Keno, Oregon, many miles above, of 1,690,000 acre-feet of water, but only 8,300 acres of agricultural land were found along it in this division, with little irrigation likely even on that. A similar situation in the matter of excess supply and small need for irrigation exists along the other large north-coast streams, viz.: Smith River, in Del Norte County, and Mad and main Eel rivers, in Humboldt County. The water supply is likewise ample for all needed or beneficial use along the smaller streams of Humboldt County, including, principally, Redwood Creek and Van Duzen, Mattole, and South Fork of Eel rivers. Because of the absence of agricultural land or due to humid conditions, very little if any irrigation is possible or needed along the immediate coast of Mendocino, Sonoma, and Marin counties, although Ten-Mile, Noyo, Albion, Navarro, Garcia, Russian, and other rivers carry relatively large quantities of water into the Pacific. In parts of the interior of these and of Lake and Napa counties, however, irrigation would be beneficial in excess of that which will be possible by direct diversion of surface streams, although in all cases the annual precipitation on watersheds adjacent to the agricultural areas would supply all needed irrigation water if it could be stored. In other cases pumping from underground waters or from lakes will give what is needed. The largest supply for irrigation in this division will come from South Fork of Eel River and its branches and from Russian River, because the largest areas of agricultural land that can be benefited by irrigation are within reach of these streams. If 100,000 acres are sometime irrigated in the northern coastal counties, 300,000 acre-feet of water will certainly be all of the water that is needed, and there can be no doubt that that quantity is within reach of land on which it can be beneficially used.

Northcentral mountain valleys.—Absence of stream gagings in this division likewise makes it necessary to use general figures in estimating the water supply at hand for irrigation. The largest agricultural areas are Shasta, Scott, Fall River, and Butte valleys. For Shasta Valley numerous perennial springs aggregating in flow about 150 cubic feet per second and underground sources furnish the most dependable supply, with large quantities of water available for direct diversion from Shasta River and its numerous tributaries in addition to the springs during spring and early summer. Klamath River has also been considered as available here, so that with some storage likely feasible on some of the Shasta River tributaries, water may be considered available for a very much larger area than the 23,800 acres now irrigated. In Scott Valley water is considered at hand if storage is feasible to water all of the 55,500 acres of agricultural land. In Fall River Valley there is a very large surplus, and in Butte Valley there is a deficiency except as underground waters may be developed. In the other areas the water supply varies from none to a sufficiency or an excess. For the entire division it is considered that the present irrigated area of

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approximately 100,000 acres can eventually be increased possibly to 250,000 acres, requiring, say, 375,000 acre-feet annually.

Northeastern plateaus and valleys.—More stream-flow records are accessible for this division than for the two just mentioned. When Big Valley was considered as a reservoir site by the Reclamation Service, it was estimated that 1,000,000 acre-feet of water would annually be available from Pit River watershed above that site, but this is in excess of the quantity that can be considered available in the sense that it can be used in this division. Counting all agricultural areas along Pit and tributaries reasonably within reach of water down to and including Big Valley, 163,300 acres were found after eliminating West and Jess valleys as probable reservoirs. For this, 500,000 acre-feet of water should be sufficient. For the Great Basin portion of this division, including Surprise and Honey Lake valleys and Madeline Plains, 400,000 acre-feet was estimated as the total water-crop that might be utilized. But considering existing conditions of land and water and that Big and Round valleys may ultimately be used for storage, doubling the present irrigated area of 161,850 acres was taken as the probable limits of future development. Assuming that meadow irrigation will continue on the lower areas in lieu of drainage and the growth of better crops, 600,000 acre-feet may be fairly considered the total quantity of water that will be used for irrigation in this big division of the State.

Feather River valleys.—Here also stream-flow records show with some definiteness the quantity of water present. The mean annual flow of Feather River at Oroville is about 6,000,000 acre-feet, with 1,649,385 acre-feet estimated as annually available above known storage sites. But only a small proportion of this is needed or can be used in the upper areas termed the Feather River valleys, the total valley agricultural land there aggregating only 158,000 acres, and only about 140,000 acres after eliminating one area of excessive elevation. Sierra Valley in this division has a large area and agriculture there is likely to attain a considerable development, but in the other valleys, of which American Valley, about Quincy, with 13,000 acres, is the largest, it does not seem likely that the character of agriculture will materially change owing to the local demand for forage, the relative inaccessibility of most of the areas, and the fixed tastes and customs of the people that will inhabit them. Allowing the usual low duty common to meadow and alfalfa irrigation in a district of ample water supply, 500,000 acre-feet may be fairly assumed as the quantity of water available for irrigation in this division.

Sierra foothills.—Although stream-flow records are available for the larger streams passing through this division, from which irrigation water comes, uncertainties as to the place or the character of future use of these streams makes it impossible to attempt a definite estimate of the water supply that can be called available for irrigation. The topographically irrigable area is estimated as 789,000 acres, with 45,250 acres now reported irrigated. Owing to the roughness and inaccessibility of much

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of the Sierra region, some land that is irrigable in the sense that it is similar to land there now being irrigated has undoubtedly been overlooked and likewise probably some has been included as irrigable that should have been omitted. But regardless of this, and the further fact that very large water supplies are within reach of some of the areas, no data are at hand that warrant estimating the ultimate area to be irrigated above 200,000 acres. Four hundred thousand acre-feet per annum would supply such an area and allow for heavy transmission losses.

Sacramento valley.—It is of course in this division of northern California that the most extensive and most important irrigation development will take place and the largest quantity of water be used. The summary of conditions there showed that the mean annual flow into Sacramento Valley at Red Bluff has been estimated to be 10,400,000 acre-feet and the mean outflow at Collinsville to be 26,000,000 acre-feet. It also showed approximately 3,400,000 acre-feet of known storage capacity for which water has been estimated to be annually available. Counting valley floor and valley plains approximately 3,500,000 acres of land-surface were found, of which it was inferred that the irrigated area may sometime be increased up to 2,500,000 acres. With necessary storage and navigation continued as at present, it was estimated that even with 2,500,000 acres irrigated, and on a liberal duty of 3 acre-feet per acre, more water would still pass unused into San Francisco Bay than now in mean years enters the valley at Red Bluff. Some of the tributaries entering Sacramento Valley below Red Bluff are of more importance in irrigation than the main Sacramento, because more easy of diversion to the irrigable lands. Stoney, Cache, and Putah creeks on the west side carry a total annual mean of more than 1,750,000 acre-feet with known possible storage on them approximating 544,000 acre-feet, counting full development of Clear Lake. Antelope, Mill, and Deer creeks, and Feather, Yuba, Bear, American, and Cosumnes rivers on the east side have a total annual mean in excess of 13,000,000 acre-feet, more than 2,000,000 acre-feet in known storage. Feather River alone was found to carry in average years enough water to cover all the valley land in Sacramento Valley to a depth of over 2 feet. Even the extensive surface supplies mentioned do not take into consideration the large supplies that now or eventually will come from underground sources. To consider total supplies as above does not, however, indicate the amounts that can be considered as available for irrigation, because minimum rather than mean years govern development and because many considerations may prevent the use of these supplies for irrigation. The total mean flow of Sacramento River at Collinsville during the months April to September, inclusive, approximates, according to the best available data, 16,000,000 acre-feet. Allowing 7,000 cubic feet per second during that period for navigation leaves nearly 13,500,000 acre-feet as an approximation of the supply available in mean years for direct diversion, assuming diverting capacity great

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enough to handle it. Including the 3,400,000 of known possible storage the total would approximate 17,000,000 acre-feet. But this large supply will never be available for irrigation, and for the purposes of this report 7,500,000 acre-feet may safely be used as the largest figure whose consideration is justified, because it is all that will ever be needed. To furnish this quantity of water in the months of April, May, June, July, August, and September, with an assumed use per acre during those months of 0.2, 0.5, 0.7, 0.7, 0.55, and 0.35 acre-foot per acre, respectively, and also to allow a continuous flow for navigation of 7,000 cubic feet per second, storage would be required in minimum years slightly above the total known to be possible. As the total flow of the entire river system is not equally distributed over the valley in accordance with the distribution of irrigable land, the total flow out of the valley at Collinsville does not, however, conclusively indicate storage necessities above the different areas. But on what appears to be a reasonable assumption with reference to navigation, viz., that it will give way to irrigation when necessary, and with the fact known that large areas in Sacramento Valley will be irrigated from underground sources, it is safe to assume that the total quantity stated as the maximum that will be needed for irrigation, viz., 7,500,000 acre-feet, may be considered available.

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IRRIGATION RESOURCES OF CENTRAL CALIFORNIA.

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INTRODUCTION.

This is the second of a series of three reports on the irrigatio resources of California prepared in coöperation between the Stat Conservation Commission of California and the United States Depart ment of Agriculture. Standards of classification similar to thos used in the two other main divisions of the State were adopted i this division, the area reported being that which is susceptible o irrigation if a water supply can be provided. Not all of the area classed as agricultural will ever be irrigated and much land include in this classification is at present and will continue to be cultivate by dry farming methods. It is intended that the agricultural land shown on the maps and included in this report shall show the limit within which the future increases in irrigation are likely to tak place, without attempting to indicate in which parts of these area the available water supply will eventually be used, as present knowl edge is not sufficient for the making of such a determination. Th discussion of the separate areas and the table inserted at the end o this report gives estimates of parts of these total areas which ma ultimately be irrigated based on the present knowledge. The area at present irrigated are from the irrigation census taken in 1910, sup plemented by field examinations to determine the changes since tha time, actual canvasses of areas being made in the more importan sections. Lands which receive water in normal years were classed a irrigated. This includes a large range of irrigation conditions, fro the economical methods used in orchards supplied by deep pumpin to the wild flooding of pasture.

Of the three parts into which California has been divided for th purposes of these reports, central California contains the largest are of both agricultural and of irrigated land. This division extends fro the north line of Contra Costa, San Joaquin, Calaveras, and Alpin counties to a line following the south line of San Luis Obispo count and extending along the crest of the Tehachapi Mountains to Tehachap and from there across the desert south of Owens Lake perpendicula to the east line of the State. This division combines the essentia and typical characteristics of both northern and southern California as in some parts of it all the products of the other two divisions ar successfully grown. All agricultural extremes are encountered fro such coast regions as Pajaro Valley, whose generally high rainfal and summer fogs make irrigation hardly necessary, to the arid po tions such as southern Kern County and the eastern desert, wher

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irrigation is essential to any crop production, and also from the low overflow areas of the San Joaquin deltas to the higher eastern Sierra valleys.

Four divisions have been made of the portion of the State treated in this report. These are: (1) the coastal valleys, (2) the main San Joaquin Valley, (3) the Sierra foothills above the San Joaquin Valley, and (4) the valleys east of the Sierra. Each of these divisions represents conditions essentially different. In the most northern of the central coastal valleys horticulture predominates, the rainfall being generally of sufficient amount to make fruit raising profitable without irrigation, although the certainty and value of the crops are increased where a water supply can be used. In San Joaquin Valley are found large compact areas of agricultural land bordering large streams, making development in large units the most economical. The agricultural lands in the Sierra foothills consist of generally separate tracts of valley and tillable bench or rolling land of small extent, where climatic conditions make profitable the growth of deciduous or citrus fruits. In the valleys east of the Sierra conditions are typical of the higher mountain areas where forage crops predominate and the methods are more wasteful and crude.

The following table summarizes the agricultural and the irrigated lands in the different divisions:

Summary of agricultural and irrigated areas in central California.

Division.	Valley agricultural land. Acres.	Valley plains. Acres.	Foothill agricultural land. Acres.	Areas irrigated. Acres.
Coastal valleys	887,000			87,000
San Joaquin Valley	6,530,000	1,046,000		1,728,975
Sierra foothills above San Joaquin Valley			777,000	10,620
Lands east of the Sierra	472,000			137,760
Totals	7,889,000	1,046,000	777,000	1,959,355

CENTRAL COASTAL VALLEYS.

The coastal valleys division includes the portion of central California lying west of the Coast Range from Contra Costa to San Luis Obispo counties, inclusive. There are 887,000 acres of agricultural land reported of which 87,000 acres are irrigated. The success attained with agriculture without irrigation, particularly with deciduous fruits, has retarded irrigation until recently. At present the realization that even better returns may be obtained with irrigation is causing much interest to be taken and development to be made in procuring water supplies. As the Coast Range receives but little snow the streams are characterized by torrential run-off, the discharge decreasing soon after the end of the rainy season and in many cases ceasing entirely,

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sometimes immediately after each storm. This lack of dependabili
in the surface flow has directed attention to the underground suppli
and these are being developed quite rapidly.

The following tabular summary groups the agricultural and t
irrigated areas of the central coastal valleys by counties and gives t
total and irrigated areas in each:

Summary of agricultural and irrigated areas in central coastal valleys.

Area.	County or counties.	Agricultural land. Acres.	Irrigated land. Acres.
San Ramon Valley	Contra Costa	6,000	
Bay Shore-Richmond-Stege	Contra Costa	50	
Lafayette	Contra Costa	1,250	
Pacheco-Concord-Martinez	Contra Costa	17,500	
Ygnacio Valley	Contra Costa	11,800	
San Francisco	San Francisco	400	
East Bay Shore	Alameda	59,500	2,
Castro Valley	Alameda	2,200	
Sunol Valley	Alameda	2,500	
Livermore Valley	Alameda	53,000	
West Bay Shore	San Mateo	33,600	1,
Pacific Shore	San Mateo	23,400	2,
Santa Clara Valley	Santa Clara	148,000	42,
Along Coast, Santa Cruz to Davenport	Santa Cruz	4,300	
Along Coast, Santa Cruz to Capitola	Santa Cruz	3,200	
Pajaro Valley	Santa Cruz	26,000	
Pajaro Valley	Monterey	6,000	
Gilroy	Santa Clara	43,000	1,
Paradise Valley	Santa Clara	3,800	
Hollister	San Benito	59,500	3,
Lower Salinas Valley	Monterey	250,000	25,
Upper Salinas Valley	Monterey and San Luis Obispo	60,000	
San Antonio Valley	Monterey	18,000	
Carmel Valley	Monterey	6,500	
San Luis and Los Osos valleys	San Luis Obispo	24,000	
Chorro Valley	San Luis Obispo	9,000	
Arroyo Grande and Los Berros valleys	San Luis Obispo	12,000	
Nipomo Valley	San Luis Obispo	2,500	
Totals		887,000	82,

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The irrigation census taken in 1910 gave the following figures on pumping from wells in the above areas in 1909:

Summary of irrigation from wells in the central coast valleys, 1909.

County.	Areas irrigated from pumped wells. Acres.	Areas irrigated from flowing wells. Acres.
Contra Costa	68	
Alameda	1,125	
San Francisco	383	
San Mateo	1,057	
Santa Clara	15,947	7,415
Santa Cruz	247	2
San Benito	1,812	847
Monterey	4,428	
San Luis Obispo	109	18
Totals	25,176	8,282

Electric transmission lines are being extended through the valley and utilized for operating irrigating pumps and a generally rapid increase in the area irrigated from underground sources is to be expected.

The streams of this division, with the exception of Salinas River, which flows parallel to the coast, have small watersheds of short length. The most important are Alameda Creek, Coyote River, Guadaloupe Creek, San Lorenzo, Pajaro, and Salinas rivers, and San Luis Obispo and Arroyo Grande creeks. Alameda Creek is largely controlled for use as a part of San Francisco's water supply and has been measured for that purpose by the Spring Valley Water Company. Various short-time records of the discharge of Salinas River and tributaries, including one for 11 years on Arroyo Seco, are available[1] but otherwise there are no public records of stream discharge.

WESTERN CONTRA COSTA COUNTY.

In the portion of Contra Costa County included in this division only 80 acres were reported as irrigated out of 36,600 acres of irrigable land. This irrigable land does not, however, include all of the land now cultivated, much of the higher areas being farmed to grain. The principal irrigable areas are the San Ramon and Ygnacio valleys and the agricultural lands in the vicinity of Concord. On the valley lands, grain, grapes, and deciduous fruits are the principal crops, the returns from the last two being generally considered satisfactory without irrigation. The nearness of these areas to the cities of San Francisco Bay with their large markets has caused the farms to be of smaller sizes, and the extension of electric railroads will increase this tendency. The local water resources are not extensive, the torrential flow of the creeks requiring storage for use. While underground sources give promise of furnishing some water, the lack of larger gather-

[1] U. S. Geol. Survey Water Supply Paper No. 300.

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ing grounds will limit the quantity of water which can be obtained The possibility of growing profitable crops without irrigation and th difficulty in obtaining water supplies make any extensive irrigatio development improbable.

ALAMEDA COUNTY.

There are two main divisions of agricultural land reported i Alameda County, that lying along the eastern shore of San Francisc Bay and that along the tributaries of Alameda Creek in Livermore an other valleys. As in Contra Costa County, much land lying above thes areas is now used for grain growing.

The area of 59,500 acres along the eastern bay shore is quite we developed agriculturally without irrigation, the land being largel divided into small tracts and intensively cultivated in truck and frui only 2,290 acres of which are reported irrigated. Aside from Alamed Creek, whose torrential flow crosses the area, the surface streams ar small and inconsequential. Alameda Creek is largely controlled fo municipal water supply and its full use for irrigation in this are is not to be expected. The development of ground water is th more probable source of supply for irrigation. Ground water occu at depths varying from 10 to 60 feet and is now used to a considerab extent for municipal supply and also to some extent for irrigatio In some places ground water is sufficiently near the surface fo crops to benefit by subirrigation. Land values are high because o the nearness of large markets and considerable expense for irrigatio will be justified, but the returns from present methods are so larg that the need of irrigation has not been generally felt. As the poss bility of larger yields possible with irrigation is recognized efforts obtain a water supply will probably be made and any available unde ground sources used as fully as practicable. The construction of an system supplying water from Sierra streams for the use of the citi lying around San Francisco Bay may affect development by releasin for irrigation water at present used for municipal supply, and al by furnishing some surplus from the Sierra source as contemplated San Francisco's latest project.

On the Alameda Creek drainage area 57,700 acres are reported irrigable if a water supply can be secured. This land is very large farmed in grain and grain hay with some grapes, while sugar bee and hops are successfully raised in a few sections. But 80 acres a reported as irrigated, the diffiiculty of obtaining a water supply havin prevented the change from the growing of grain to the more intensi irrigated crops. About 400 square miles of the drainage area trib tary to Alameda Creek are available for these areas but the torrenti character of this stream makes storage necessary for its use f irrigation. The water supply of this stream has been quite extensive investigated and purchased for use as a municipal supply. Storage Arroyo Valle and pumping from the lower gravel beds where son

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artesian flow is now obtained are contemplated. The extensive use of any local supplies for irrigation is not probable, although here, as along the east bay shore, the development of new municipal water supplies for the bay cities may furnish some excess for irrigation.[1]

The nearness of large markets would make profitable the use of any available supplies in the intensive cultivation of garden truck and small fruits.

SAN MATEO COUNTY.

In San Mateo County a total of 57,000 acres of irrigable land are reported of which 3,670 acres are irrigated. This area is quite highly developed, much garden truck being grown for the nearby city markets. Land holdings are small, much of the land along the transportation lines being divided into suburban building sites. Present irrigation supplies are secured largely by pumping from the small creeks, although underground water is found at depths of from 20 to 50 feet and should be sufficient to supply a considerable area, particularly near the various streams. Artesian flow occurs near Redwood at depths of 200 to 300 feet.

On the west shore of San Francisco Bay 1,230 acres of the 33,600 acres of agricultural land reported are irrigated, chiefly in the vicinity of Colma. There are about 65 square miles of local drainage area, exclusive of San Mateo Creek, which is controlled by the Spring Valley Water Company for municipal use. With storage this would supply about one third of the area, although its full use is not probable because of the small size of the various streams. Along the ocean shore, 2,440 acres of agricultural land are irrigated, about two thirds of this being in the vicinity of Half Moon Bay and one third along San Pedro Creek. There are about 200 square miles of tributary drainage area divided between several small creeks which with sufficient storage might supply the area with water. Data on possible storage sites are not available, but full development is not to be expected. The present returns from unirrigated crops are so large that there has been no general demand for irrigation, although its benefits are becoming appreciated. Increase in the irrigated area is to be expected, although more by the use of underground supplies than by storage on the small creeks.

SANTA CLARA VALLEY.

This name is generally applied to the area in Santa Clara County centering around San José and extending south along Coyote Creek to the divide near Morgan Hill. There are 148,000 acres of agricultural land in the valley and lower hills of which 42,550 acres are irrigated more or less completely. This irrigated area is bordered by foothill land which is used to some extent for both fruit and grains, but which has been excluded in this classification as no water supply

[1] Various unpublished reports submitted to Board of Army Engineers in the matter of the application of San Francisco to use Hetch Hetchy Valley as a reservoir.

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for irrigation can be considered as available. In this valley, which is noted as a prune and other deciduous fruit center, irrigation was long considered as not increasing the yields and returns in proportion to its cost. In recent years this feeling has rapidly changed until at present practically all of the torrential discharge of the various local creeks is diverted for irrigation in the winter or spring as it may be available, and underground resources are being drawn upon at a rapidly increasing rate, there having been an increase of over 25 per cent in the area irrigated from pumps between 1909 and 1912.

The soils here vary from sandy loams to black adobe,[1] the latter being found in the lower areas near San Francisco Bay. Owing to the heaviness of the soils and the generally unfavorable drainage conditions the use of these lands bordering San Francisco bay has been confined to the growing of vegetables and forage crops. The soils of the higher valley lands are in many places underlaid by clays which assist in the retention of the water applied in winter irrigation. Alkali occurs in injurious quantity only near the marsh lands, and hardpan does not interfere with agriculture in this area. In the orchards where water supply for irrigation can not be obtained, thorough cultivation and the use of a cover crop during the winter which is plowed under in the spring are used to conserve moisture and soil fertility. As a rule the orchards are owned in small tracts, 15 to 40 acres being usual and the agricultural methods are thorough and progressive. Los Gatos, Guadalupe, and Campbell creeks and Coyote River are the principal streams, the total drainage area tributary to the valley being about 1,350 square miles. These streams have surface flow during the rainy season only and are generally dry by May. The total run-off and consequently the area irrigated varies with the different years. In 1912, which was a year of low run-off, 8,200 acres received water from Campbell, Los Gatos, and Guadalupe creeks, and in 1909 the census returns gave 9,700 acres irrigated from these same streams. Orchards are the principal crop irrigated, furrows or flooding in basins being the usual methods of application. While it might be feasible in some cases to construct small reservoirs for the storage of part of the discharge of these streams for use in the later season the use of winter irrigation and ground storage, even although perhaps not as efficient, is cheaper and probably more economical in view of the irregular character of the stream discharge. Artesian flow is obtained north of San José and extending to San Francisco Bay and is used for the irrigation of about 7,000 acres largely of vegetables and alfalfa. In the remaining valley lands underground water occurs at depths varying up to 100 feet, or over in a few cases, the lesser depths being found near the creek beds, although in the section most largely developed at present, lifts of 40 to 75 feet are the most usual. Near the foothills the depth to water increases and the quantity obtainable decreases so that pumping for irrigation is impracticable.

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of San José Area.

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Owing to the adaptability of this section to the growing and drying of fruit, especially prunes and apricots, a considerable expense for obtaining a water supply for irrigation is warranted and the present rate of increase in pumping plants indicates that the benefits derived from their use are greater than their cost. The underground water should be capable of much additional development, although there are no data available on which an estimate can be based of the total amount which may ultimately be supplied from these sources. The tributary gathering ground exceeds 1,000 square miles on which the annual rainfall varies from 15 inches in the lower valley to over 30 inches in the surrounding ranges. As the surface soils are usually open and the precipitation generally occurs in separate rains of moderate amount, conditions for the absorption of a comparatively large portion of the rainfall are favorable. Water is now being raised from depths which would formerly have been considered impracticable, and a continuation of the development of pumping for lands where soil and other conditions make the growth of orchards profitable is to be expected.

MINOR AREAS IN SANTA CRUZ COUNTY.

SANTA CRUZ TO DAVENPORT.

This area comprises 4,300 acres forming a narrow strip along the Pacific Ocean extending northwesterly about 12 miles from Santa Cruz. Numerous creeks which have their source in the Santa Cruz mountains dissect the area and find their outlet in the ocean. Between the creeks the land is rolling and devoted almost exclusively to the growing of grain and grazing of cattle. No irrigation is reported and, owing to the limited agricultural area and the torrential character of the run-off, it is doubtful if storage would prove feasible.

SANTA CRUZ TO CAPITOLA.

This area comprises 3,200 acres extending easterly from Santa Cruz to Capitola. A few miles back from the ocean the land becomes rolling and gradually merges into the mountains. The soil varies from a sandy loam to a black adobe. The holdings average about 40 acres in extent and the land is valued at $250 to $400 per acre. Deciduous fruits and grapes are grown with a considerable area devoted to truck farming. About 520 acres are irrigated by pumping from streams and wells. The pumping plants are small, deep-well pumps being commonly used, the lift varying from 40 to 60 feet. Increased irrigation development will depend principally upon storage of creek waters but the agricultural area is so small that it is doubtful if the expense of storage reservoirs would be justifiable.

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AREAS IN PAJARO RIVER DRAINAGE.

In the Pajaro River drainage are several areas of agricultural land which are more or less continuous. Two of these are in the lower portion known as Pajaro Valley, one lying north of the river in Santa Cruz County, consisting of 26,000 acres of agricultural land of which 670 acres are irrigated, and the other lying south of the river in Monterey County, containing 6,000 acres, of which 700 acres are reported irrigated. In the vicinity of Gilroy, in Santa Clara County, is an area of 46,800 acres, of which 1,220 acres are irrigated, 3,800 acres of the agricultural and 20 acres of the irrigated land being in Paradise Valley. The area extends northwest to the divide into Santa Clara Valley at Morgan Hill. In San Benito County are 59,500 acres in the vicinity of Hollister, of which 8,300 acres are irrigated. These units make a total of 138,300 acres of agricultural land, of which 10,890 acres are now irrigated.

Pajaro River has a total drainage area of about 1,300 square miles, the mean annual rainfall on which varies from 10 inches to 25 inches and probably averages 15 inches. No long-time discharge records are available but present use is much less than the run-off, as even in the dry season water escapes to the ocean. San Benito River is the largest tributary, Llagas, Uvas, and Pacheco creeks being the others of importance. Any extensive use of Pajaro River or its tributaries for irrigation will require storage as its flow is largely torrential because of the lack of drainage areas extending to regions of snow. Some sites for storage are known. One reservoir on San Benito River to contain 4,500 acre-feet is being built, and other sites probably exist which it will be practicable to utilize if the demand for their use arises. Underground water conditions are also generally favorable, particularly in those portions lying near any of the streams. About one half of the present irrigated area is supplied with water by pumping from this source. Artesian flow is also encountered in various places.

PAJARO VALLEY.

The lower portion, the so-called Pajaro Valley, is best known agriculturally for its apples and berries, more apples being shipped from this section than from any other in California. Owing to the generally high rainfall, 23.7 inches annually at Watsonville, irrigation of mature orchards is not considered to increase the yields in proportion to its cost. Such irrigation as is practiced consists mainly of the pumping of water for use on berries and other inter-crops in young orchards. As the returns from unirrigated orchards are satisfactory to their owners no large increase in irrigation is to be expected. During the summer dry season, the cool fogs are of much benefit in reducing evaporation and possible sunburn in the apples. During the winter the hills which practically surround the valley aid in protecting the orchards from sudden temperature changes. Sugar beets and potatoes

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are also important crops in the lower lands, while on the higher valley lands and hills barley and oats are extensively grown. Up to the present time irrigation has been confined to portions of the more productive alluvial bottom lands the total area of which is about 18,000 acres.

The soils are variable, loams and sandy loams comprising the largest acreage with the heavier soils found in the lower portions.[1] The only use of Pajaro River for irrigation has been by pumping, the lifts being from 20 to 40 feet. Browns Creek is tributary to the river, entering from the north in this area. In the lower bottoms sufficient water for irrigation can be obtained from wells at lifts of approximately 20 to 50 feet. At various times much of the present orchard land has been irrigated, the prevailing practice being to plant the various types of berries such as blackberries, raspberries, loganberries, or strawberries, and in some cases sugar beets between the rows of young trees and to irrigate the whole until the orchards come into bearing. Irrigation of mature orchards is not practiced and as the soils adapted to apples are quite largely used for them, at present the areas available for irrigation are not extensive. Some alfalfa is irrigated but land is generally considered too valuable to be used for this crop. It is not probable that irrigation will ever be developed in this valley even to the extent of the available water supply, as the lands for which a water supply can most readily be obtained are those on which its use is the least needed. While the irrigation of the higher lands would be of benefit the cost has up to the present prevented any attempts being made to provide a water supply for them.

Pajaro River flows through a narrow valley above Chittenden which widens above the mouth of San Benito River, forming the valley extending from Gilroy for 12 miles northwest in Santa Clara County along Llagas and Uvas creeks, and also the area in San Benito County along the San Benito River and around Hollister.

GILROY AREA.

In Santa Clara County a mixed development is found, part of the land being in small holdings and intensively cultivated in fruit and other crops similarly to Santa Clara Valley to the north, and part still remaining in the large grants, of which but slight agricultural use is made. The rainfall is higher than in the areas farther north, being about 19 inches at Gilroy. Llagas Creek, the largest stream, drains about 80 square miles of low hills, the run-off being torrential and irregular. The land along upper Llagas Creek is known as Paradise Valley and is a highly developed prune district. Present irrigation is mainly by pumping, the under flow of Llagas Creek being available in the lower lands along its course. Artesian flow can be secured southeast of Gilroy in the lower areas. With the subdivision of the large holdings and the continued increase in irrigation from pumps, this area should reach development similar to the Santa Clara Valley.

[1] U. S. Dept. Agr., Bureau of Soils. Soil Survey of Pajaro Valley, Cal.

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HOLLISTER AREA.

In San Benito County irrigation is more largely practiced, San Benito River being the main source of supply. Dairying is more prominent here than the fruit industries. A ridge of low hills separates the valley along the lower San Benito River from the main areas around Hollister, forming the San Juan Valley, containing about 10,000 acres which are largely planted in orchards. North of Hollister is an alkaline area of swamp and overflow land of which 10,000 acres are as yet unreclaimed and have been excluded from the classifications of this report. Owing to the smaller rainfall, the mean annual precipitation at Hollister being about 12 inches, irrigation is more necessary than in the valleys to the north. About 3,300 acres are irrigated by gravity canals from San Benito River, winter flooding methods being used. The increase of this acreage is contemplated, as through storage the discharge of San Benito River can be made to serve much more land, the total drainage area being about 700 square miles. Underground water in sufficient quantities for pumping is obtainable under the valley land, becoming scarce near the foothills. This is also used at present as well as the artesian flow which can be obtained in the northern portion. Increase in irrigation, both from streams and from ground water, can be expected in this area.

SUMMARY.

Of the total of 138,300 acres of agricultural land reported in the various areas in the Pajaro River drainage, but 10,890 acres are irrigated at present. The success which has been attained without irrigation has caused less interest to be taken in procuring a water supply than would have otherwise been the case. This also renders uncertain any estimate of the area which may eventually be irrigated although it is probable that all accessible sources of water supply will ultimately be utilized. Sufficient records are not available on which an estimate of the total water supply can be based. The irregular and torrential character of the discharge of the surface streams will limit their use largely to winter flooding as being cheaper than storage in reservoirs. The greatest dependence will be placed upon underground supplies and these should be capable of irrigating several times the present area. Their use is more probable in the Gilroy and Hollister sections as rainfall and climatic conditions are less favorable there than in the lower Pajaro Valley. The drainage area is about the same size and the general precipitation probably but little more than one half that of the Santa Clara Valley, in which over 40,000 acres are irrigated without having nearly reached the practicable limit, and the ultimate irrigation of nearly 40,000 acres should not be impracticable in the Pajaro River drainage.

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SALINAS VALLEY.

Salinas Valley comprises the largest area of agricultural land in the coast division. It extends in a southeasterly direction from the bay of Monterey to its head in San Luis Obispo County, a distance of about 100 miles. The valley is separated from the Pacific Ocean on the southwest by the Santa Lucia Range and on the northeast is separated from San Joaquin Valley by the Mt. Diablo Range. Salinas River forms the main drainage artery and with its tributaries drains 4,780 square miles.

For the purpose of this report Salinas Valley is divided into lower Salinas Valley and upper Salinas Valley, the division line being taken a few miles southeast of King City, where the valley becomes a narrow strip along the river.

LOWER SALINAS VALLEY.

Lower Salinas Valley lies entirely in Monterey County, is from 7 to 9 miles wide, and comprises 250,000 acres. This area is about equally divided between uplands or plains bordering the foothills and bottom or valley lands. The uplands are devoted almost exclusively to the growing of grain and consist of a soil of loose, coarse texture. The bottom lands are of various grades of sand, sandy loam, and adobe.[1]

The discharge of Salinas River near Salinas was measured from January, 1900, to July, 1901.[2] Comparison of this with the records on Arroyo Seco covering 11 years indicate the probable total mean annual discharge of the Salinas to be between 500,000 and 600,000 acre-feet. The annual discharge in dry years is about 200,000 acre-feet. The run-off is not largely used, mainly because of its torrential character to the depth of the stream bed below much of the land, and the success in growing large acreage of grain without irrigation.

There are six canals diverting water from the Salinas River and its main tributaries, the Aroyo Seco and San Lorenzo River, irrigating about 11,500 acres of land. Four of these canals are controlled by a local sugar company. Extension of irrigation from gravity supply must depend principally upon the storage of flood waters. The United States Geological Survey has made surveys and reported on the storage of Salinas River.[3] Two sites on the Arroyo Seco were favorably reported upon, having a combined capacity of 41,367 acre-feet. It is estimated that the reservoirs can be filled once in dry years and twice in ordinary years, being emptied once for winter irrigation. On San Lorenzo Creek, the Mathews reservoir was surveyed and the water supply estimated to be 4,000 acre-feet in dry years and 12,000 acre-feet in ordinary years. Assuming the duty of water to be 2 acre-feet per acre per season, these reservoirs if built would provide water in ordinary

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Lower Salinas Valley.
[2] U. S. Geol. Survey Water Supply Paper No. 300.
[3] U. S. Geol. Survey Water Supply and Irrig. Paper No. 89.

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years for 46,000 acres. Other reservoir sites were examined but under present conditions the cost of storage was not considered justifiable, although ultimately the sites may be used.

Irrigation by pumping from wells or from stream channels has increased in large proportions in the last few years. In 1912 there were over 100 pumping plants in the valley providing water for 13,500 acres of land, or nearly three times the area reported by the census of 1909. Underground waters in sufficient amounts for use in irrigation underlie most of the lower valley lands at lifts varying from 20 to 40 feet. With the advent of electric power in the valley in 1912 and the more general attention given to irrigation, pumping will be the source of much future development.

The principal crops irrigated are beets and alfalfa, and in the adobe soils one heavy irrigation applied in the winter has been found sufficient. Grain constitutes one of the staple crops of the valley and is grown without irrigation. As in many parts of California where wheat and barley have been grown successively for many years, the yield has decreased and the soil depleted. Attention is now being diverted to other crop pursuits, chief of which are sugar beets, alfalfa, and potatoes. One serious handicap to agricultural development has been the vast single land holdings. In the drainage basin of Salinas River 51 ranchos covered an area of 570,000 acres. A large number of these ranchos remain intact but they are gradually being subdivided into small tracts. Another factor that has retarded irrigation development in Salinas Valley is that until recently the rainfall was considered sufficient for agriculture. The average annual precipitation at Salinas covering a period of thirty years is 14.71 inches, with seasonal fluctuations of from 5 to 20 inches. This wide variation and uncertainty in the rainfall has impressed upon the residents of the valley the need of irrigation. The winds have a marked influence upon the climate. During the dry season trade winds enter the valley from Monterey Bay which give way in the winter to winds from the southeast frequently accompanied by rain. Fogs which prevail during the dry season also play an important part in the climate by conserving soil moisture and checking evaporation. With the subdivision of the large holdings and the increase in the acreage being planted to sugar beets, potatoes and alfalfa, instead of grain, the outlook for irrigation extension is promising.

UPPER SALINAS VALLEY.

Upper Salinas Valley extends from King City to about 9 miles southeast of Santa Margarita, comprising 60,000 acres. Above King City the valley narrows to about a mile in width, and from Wunpost to San Miguel the river flows in a deep, wide canyon. The valley widens again southeast of Paso Robles and from that point to its head is cut by numerous channels and broken rolling hills.

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The upper Salinas Valley is devoted almost exclusively to the growing of grain and the live stock industry. Small fields of alfalfa are irrigated along the bottom lands by pumping from the stream or from wells. The area irrigated in 1912 was 300 acres.

Near Paso Robles artesian water has recently been struck at a depth of 325 feet and present indications are that sufficient water can be obtained for irrigating most of the available agricultural area in that vicinity.

SAN ANTONIO VALLEY.

This is a mountain valley with an average elevation of 1,000 feet lying west of the upper Salinas Valley and comprises about 18,000 acres. It is an old settled section, being founded a century ago, and is devoted almost exclusively to the growing of grain and raising of cattle. The valley floor is covered with scattered oak timber, giving a park-like appearance. San Antonio River has been explored for reservoir sites, but the only one found available is a considerable distance below the body of agricultural land. Sufficient water for stock and domestic purposes is obtained from wells at depths ranging from 25 to 40 feet. There are not enough wells on which to base an opinion as to underground water conditions, but it is not probable any extensive irrigation will take place in this valley from underground sources.

CARMEL VALLEY.

This is a small coast valley drained by the Carmel River which enters Carmel Bay about 4 miles below Monterey. The valley is from ¼ to ½ mile in width and the area embraced in this report covers about 6,500 acres. The soil ranges from a sandy loam to a black adobe along the river bottoms. The waters of Carmel River are utilized by Pacific Grove and Monterey for municipal purposes. Alfalfa is grown in the bottom lands with subirrigation and aside from this no irrigation is practiced. Dairying and stock raising form the principal industries, although deciduous fruits are successfully grown. Irrigation development in this area will probably follow along lines of pumping from underground sources.

SAN LUIS OBISPO COUNTY AREAS.

SAN LUIS AND LOS OSOS VALLEYS.

These are two adjoining valleys in San Luis Obispo County comprising 24,000 acres. In common with other Coast Range valleys they have a northwest-southeast trend. The average elevation is 200 feet. The combined length of the valleys is about 20 miles and the width varies from 1 to 4 miles.

Drainage is afforded San Luis Valley by San Luis Obispo and Pismo creeks, which find an outlet in the Pacific Ocean. Los Osos Valley is drained by Los Osos Creek, which flows northwesterly into Morro

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Bay. The average annual rainfall at San Luis Obispo covering a period of ten years is 21 inches. Grain and beans are the principal crops grown, with an increasing acreage of alfalfa, and more attention is being given to irrigation. There are only a few small pumping plants, irrigating about 80 acres. Where wells can be sunk in old stream channels water can be obtained in sufficient quantities to irrigate small areas.

CHORRO VALLEY.

This valley comprises 9,000 acres of agricultural land which lies along Chorro Creek northwesterly to Morro Bay. Conditions are similar to those in Los Osos Valley except that more irrigation is practiced, the area watered being 640 acres. This consists of small fields of alfalfa found along the creek bottoms. Irrigation may be extended by building small storage reservoirs on creeks that enter the valley, but it is doubtful if the area that could be irrigated would justify the expense.

ARROYO GRANDE AREA.

This includes Arroyo Grande and Los Berros valleys, together comprising 12,000 acres. The valleys are located in the southwestern portion of San Luis Obispo County and except along the Pacific are surrounded by broad rolling hills or mesas. Drainage is afforded by Arroyo Grande, Los Berros, and Pismo creeks, which find their outlet in the Pacific. Arroyo Grande Valley is highly developed and widely known for its seed farms. Other important crops are beans, sugar beets, grain and walnuts. Land is held in small tracts averaging 40 acres. Arroyo Grande Creek is the source of supply for three irrigation companies which irrigate about 500 acres. Generally one or two heavy irrigations in the winter are sufficient for beets or alfalfa, which are the only crops irrigated. Storage will be necessary for any further extension. Pumping from wells has not been resorted to and the data on underground supply is therefore meagre. Water is obtained from 15 to 30 feet below the surface and should afford sufficient supply for irrigating small areas.

NIPOMO VALLEY.

Nipomo Valley is separated from Los Berros Valley by a low range of hills and extends southwesterly from the summit to Santa Maria River, a distance of about 6 miles. South of Nipomo the valley is dissected by several small streams or arroyos and is broken by low rolling hills. The area comprises 2,500 acres and no irrigation is reported. The valley is devoid of timber and brush and the soil is mostly black adobe. Almost the entire area is farmed to grain in large holdings with an increasing acreage in beans. The depth to water in a few domestic wells in the valley ranges from 25 to 40 feet and sufficient water is afforded for stock and domestic purposes. From the scant information on the underground supply, it seems possible that small areas can be reclaimed by pumping from wells.

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SUMMARY.

The agricultural land in the various areas reported in the central coastal valleys totals 887,000 acres, of which 82,000 acres are irrigated. The water supply for about two thirds of this is obtained from surface streams either by gravity diversion or by pumping. Owing to the torrential character of all streams draining the coast range in central California complete seasonal irrigation from surface supplies as practiced in the other divisions is not possible without storage. As yet the benefits of irrigation have not been sufficiently recognized to make feasible large projects which alone could afford expensive storage, the opportunities for which are not generally favorable. The largest existing canal system irrigates less than 4,000 acres.

Underground waters, either pumped or flowing, now supply over one third of the present irrigated area and their use is increasing at a more rapid rate than that of the surface streams. No detailed study has been made of the amounts which can be secured from the groundwaters without depleting the supply, but it is certain that present development takes much less than can be safely withdrawn. The greater reliability of groundwater supplies as contrasted with the variable flow of the local streams, and the better adaptability of the former to the small units in which the more intensively cultivated irrigated land is usually held, make their full use the most natural development.

In practically all agricultural areas in this division or at least in as large parts of them as the available water resources can supply, crops of high returns can be grown so that a comparatively large expense for irrigation may be justified. That the benefits are becoming appreciated is evident from the increase in use of pumping plants and other sources that is now taking place, although in many portions the profits without irrigation are sufficient to satisfy the landowners, particularly those with large holdings. It is this ability to produce crops without irrigation that makes difficult any forecast of future development. It is not improbable that 70,000 acres will be irrigated in Santa Clara Valley and 40,000 in the Pajaro River drainage. It has been estimated that 65,000 acres[1] can be supplied with water from surface resources in Salinas Valley and with full use of underground waters this figure may be exceeded.

Including the other smaller areas it is reasonable to expect that a total of 200,000 acres will eventually be irrigated and even this acreage may be exceeded. Were these coast valleys located where irrigation is a necessity it is certain that their water resources would be made to serve greater areas than these. The ultimate irrigation of 200,000 acres is an increase of less than one and one half times the present development. Until recently it has been maintained in many of these valleys that irrigation was neither a necessity nor a benefit, and much additional use of the available water supply both in small pumping units and by canals and storage is to be expected.

[1] U. S. Geol. Survey Water Supply and Irrig. Paper No. 89.

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SAN JOAQUIN VALLEY.

The division which consists of the main San Joaquin Valley is the largest irrigated section in the State, both in the area at present irrigated and in its prospective development. It includes the lands lying in the main valley floor and in the adjacent more or less rolling plains through which the valley trough blends into the higher Sierra foothills. On the western side of the valley, because of unfavorable topographic and climatic conditions, no land is classed as irrigable and agricultural except that lying in the valley, the division between valley and hills generally being distinct. On the eastern side there is an area of varying width which differs both from the valley lands and from the distinctly foothill lands. This has been classed as a plains area and is tabulated separately from the valley land in the summaries. In the northern portion of the valley this plains area, which lies mainly above present canal systems, is used principally for grain raising, while in some of the southern sections, as in the vicinity of Porterville, citrus fruit growing has been developed, although in the southern portion, because of the lack of an adequate water supply, the plains in the main have been but little used for agriculture. Lying higher than the plains area and in scattered valleys and flats are agricultural lands which, because of their differences both topographic and climatic, have been classed as a separate division and are discussed under the head of Sierra foothills. The division between these areas is not distinct in many cases and their classification is partially a matter of personal judgment.

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Summary of agricultural and irrigated areas in San Joaquin Valley.

Area.	County or counties.	Valley lands.		Plains lands.	
		Total agricultural. Acres.	Area irrigated. Acres.	Total agricultural. Acres.	Area irrigated. Acres.
Areas south of San Joaquin River:					
Southern Kern County	Kern	390,000	115,500	228,000	570
Wasco	Kern	368,000	32,500	81,000	----
Lands along Buena Vista Slough	Kern	116,000	40,000	----	----
Antelope Plains west side valley	Kern	304,000	----	----	----
White and Deer creeks	Tulare	181,000	7,600	37,000	1,430
Porterville	Tulare	162,000	38,010	37,500	11,710
Kaweah River	Tulare and Kings	342,000	117,550	37,000	7,130
Valley lands south and west of Tulare Lake	Tulare and Kings	240,000	58,420	----	----
Present area of Tulare Lake	Kings	[1]133,000	----	----	----
Valley lands west of Tulare Lake	Kings	119,000	----	----	----
Alta	Fresno	147,000	93,960	39,000	1,130
Hanford	Kings	226,000	159,360	----	----
Fresno	Fresno	535,000	325,400	44,500	1,220
Murphy Slough	Fresno	135,000	77,840	----	----
Jamesan	Fresno	130,000	43,000	----	----
West side, north of Tulare Lake	Fresno and Kings	763,000	4,580	----	----
Totals	----	4,158,000	1,113,720	504,000	23,190
Areas north of San Joaquin River:					
West side, Firebaugh to Crows Landing	Fresno, Merced, and Stanislaus	367,000	127,250	----	----
West side, Crows Landing to Tracy	Stanislaus and San Joaquin	143,000	6,200	----	----
West side, Tracy to Bay Point	San Joaquin and Contra Costa	66,000	----	----	----
Madera	Madera	390,000	43,000	112,000	40
Merced	Merced	361,000	84,895[2]	112,000	[3]
Modesto-Turlock	Stanislaus and Merced	315,000	135,760	135,000	----
South San Joaquin-Oakdale	Stanislaus and San Joaquin	129,000	4,000	110,000	----
Stockton	San Joaquin	256,000	13,320	73,000	----
San Joaquin delta lands	Contra Costa and San Joaquin	315,000	177,600	----	----
Totals	----	2,372,000	592,025	542,000	40
Grand totals	----	6,530,000	1,705,745	1,046,000	23,230

[1]Not included in total.

[2]Includes all land holding water rights from Crocker-Huffman canal; only 19,500 acres actually received water in 1912.

[3]Not segregated from valley irrigated areas.

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The separate areas of San Joaquin Valley division as they h
been segregated for study are shown in the accompanying table,
total being 7,576,000 acres, of which 6,530,000 acres are in the va
floor and 1,046,000 acres in the plains area. Of this total, 1,728,
acres are at present irrigated. The remaining 5,847,025 acres repre
the area in which future increases in irrigation will take place. W
this land is susceptible of irrigation from some source of water sup
excepting part of the west side, its total extent exceeds that which f
present information the water resources can be considered as cap
of supplying. The discharge of the main streams has been measu
sufficiently to enable their possibilities to be estimated with s
definiteness, but the underground resources while known to be la
can not be similarly stated.

Records of the discharge of the streams in San Joaquin Va
generally cover longer periods than those for Sacramento Valley,
examinations for storage sites are not available for as much of
drainage area. More use is made of the run-off than in the Sacrame
Valley, the natural flow of several streams being quite fully dive
during most of the year. The failure to store the flood waters is
to some extent to the present legal uncertainties which would be invol
in any storage which would conflict with riparian right. The y
1897-98 showed the lowest discharge of any of the years covered
stream records. Only the larger rivers were measured during t
year, although the five gaged furnished about two thirds of the t
discharge. By estimating the others by comparison with other
years, the total mean annual discharge in the year of lowest discha
appears to have been about 4,740 cubic feet per second for the stre
from San Joaquin River north, and 2,060 cubic feet per second
Kings River and those to the south, a total of 6,800 cubic feet
second, equivalent to about 4,900,000 acre-feet for the year. Thi
only 40 per cent of the flow during years of average run-off. The t
mean annual run-off as shown by accompanying table has been app
imately 12,000,000 acre-feet, or sufficient, if its complete use w
practicable, to irrigate 4,000,000 acres at a duty of 3 acre-feet per a
While the seasonal use of water has been quite largely adapted to
variations in stream-flow, the utilization of the entire run-off wo
require more storage capacity to equalize both seasonal and ann
variations in flow than can be provided at practical costs. The foll
ing table gives the general data regarding the mean discharge of
measured streams:

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Table showing drainage areas in square miles and mean monthly and annual flow in cubic feet per second of streams in San Joaquin Valley.

Stream and measurement at edge of foothills.	Number of years.	Drainage area. Square miles.	Mean flow in cubic feet per second. October	November	December	January	February	March	April	May	June	July	August	September	Mean flow.	Total mean annual run-off. Acre-feet.
San Joaquin River and north:																
[2]Mokelumne	12	657	136	272	495	847	1,300	1,940	3,040	3,640	3,230	1,320	257	111	1,380	1,000,000
[1]Calaveras	6	491	12	29	135	492	1,172	1,344	1,832	961	217	49	2	0	520	377,000
[2]Stanislaus	18	1,051	232	362	609	1,260	1,970	3,160	4,160	5,010	4,240	1,600	361	179	1,930	1,400,000
[2]Tuolumne	21	1,635	420	694	989	1,700	2,420	3,660	5,380	7,650	7,570	3,140	645	221	2,870	2,080,000
[2]Merced	15	1,090	257	234	473	1,050	1,440	2,300	3,130	4,630	4,190	1,810	452	185	1,700	1,228,000
[1]Bear	6	166	3	4	25	46	171	219	212	67	28	11	0	0	65	47,000
[1]Mariposa	6	122	0	3	20	36	129	162	122	50	22	8	0	0	46	33,000
[1]Chowchilla	6	268	0	9	45	78	359	535	466	172	136	45	3	0	152	110,000
[1]Fresno	6	272	0	0	64	123	392	568	475	194	143	45	5	0	167	121,000
[2]Upper San Joaquin	16	1,640	437	565	889	1,710	1,930	2,330	4,380	8,090	8,520	3,650	1,140	527	2,850	2,060,000
Totals	11	7,392	1,497	2,172	3,694	7,342	11,283	16,218	23,197	30,464	28,296	11,678	2,865	1,223	11,690	8,456,000
South of San Joaquin River:																
[2]Kings	23	1,740	453	447	572	1,170	1,240	2,140	4,090	7,770	8,280	4,000	1,140	464	2,647	1,920,000
[2]Kaweah	13	520	120	107	205	423	628	906	1,280	1,890	1,950	917	230	177	736	533,000
[3]Tule	9	266	32	45	116	274	262	433	467	416	276	84	27	22	204	148,000
[2]Kern	22	2,345	334	343	405	561	708	977	1,699	2,560	2,675	1,500	642	361	1,063	770,000
[1]Caliente	6	423	0	50	100	180	475	562	504	287	110	3	0	0	191	138,000
[1]Poso	6	289	5	34	64	126	325	384	345	198	75	2	0	0	128	92,000
[1]White	6	90	3	11	20	38	101	119	107	61	23	1	0	0	40	29,000
[1]Deer	6	110	4	13	26	49	124	143	131	75	29	1	0	0	49	35,000
Totals	11	5,783	951	1,050	1,508	2,821	3,863	5,664	8,623	13,257	13,418	6,508	2,039	1,024	5,058	3,665,000
Grand totals	11	13,175	2,448	3,222	5,202	10,163	15,146	21,882	31,820	43,721	41,714	18,186	4,904	2,247	16,738	12,121,000

[1]Records California Engineering Department, 1878-84.
[2]Records California Engineering Department, 1878-84, and Geological Survey for remainder.
[3]Records U. S. Geological Survey.

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The underground water is one of the greatest water resources of S Joaquin Valley and its use is increasing rapidly, although consider the valley as a whole its development is just beginning. In s localities, as around Stockton and Fresno, pumping plants are numerous, but further increase in the areas irrigated by this mean being made. Artesian flow can be secured in many parts of the lo valley floor and is used to some extent for irrigation, as at Corco and Semitropic. Parts of the west-side areas are the only portion wh at least some underground water can not be obtained for irrigat The ultimate development of 5,000 cubic feet per second from und ground sources has been estimated as possible in the entire valley.[1]

The following table shows the area irrigated from wells as given the census of 1909, and also the area at present irrigated from source, as determined from the field work for this report, the incre for the three years having averaged 30 per cent per year:

Irrigation from underground waters, San Joaquin Valley, 1909.

County.	Census of irrigation for 1909.			Area reported irrigated in 191
	Area irrigated by pumping plants. Acres.	Area irrigated from flowing wells. Acres.	Total irrigated from ground waters. Acres.	Acres
Kern	4,290	2,097	6,387	1
Tulare	31,286	6,656	37,942	7
Kings	1,042	11,400	12,442	3
Fresno	21,729	----------	21,729	2
Madera	1,663	----------	1,663	
Merced	2,002	262	2,264	
Stanislaus	5	----------	5	
San Joaquin	8,642	----------	8,642	1
Totals	70,659	20,415	91,074	17

The necessity of irrigation was early appreciated in the south end of San Joaquin Valley, and farming without it has been attemp but little south of Kings River. The benefits resulting from the use water have become so well recognized that but little land is dry-farm except from the lack of an available water supply. In the north portion of the valley the higher rainfall and more retentive soils in so localities have made profitable the raising of grain, as well as so orchards and vineyards, without irrigation, but these sections are rapidly coming to an appreciation of the benefits of irrigation.

The climate shows a quite regular variation from the north to south, the rainfall decreasing from 15.4 inches at Stockton to less th 5 inches at Bakersfield, and the mean annual temperature increas from 59 degrees at Stockton to 66 degrees at Bakersfield.

A great variety of crops can be grown successfully, which allows individual farmer much choice in this regard. Forage crops, b alfalfa and wild hay, are extensively raised for both dairy and st

[1] U. S. Geol. Survey Water Supply Paper No. 222.

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feeding. All classes of deciduous fruits and grapes are produced in large quantities. Sugar beets are successfully grown to a small extent, which will increase, although the present profits from other crops requiring less labor tend to retard increase in beet acreage. But little grain is irrigated except on the large holdings. In the delta lands truck gardening and potato raising predominate. The different sections tend to specialize in one or two crops for which their local conditions may be best adapted, such as sweet potatoes in parts of Merced County.

The soils of the valley in general are sandy, sand and sandy loams predominating. Heavier soils occur in some places, as on the overflow lands along the rivers. A considerable proportion, particularly on the east side, is underlaid with hardpan of varying thickness occurring at varying depths. However, this hardpan seriously interferes with cultivation in but a few scattered localities. Over-irrigation and lack of drainage, have rendered much land unproductive from alkali, but proper cultivation and reclamation can restore much of this land to productivity.

The topography shows but few features. Kings River and Los Gatos Creek have built their deltas across the valley, forming a ridge which prevents the waters of the streams south of Kings River reaching the lower valley except upon the occasion of rare floods. The excess flow of the southern streams forms Tulare Lake, which fluctuates in size and depth with the varying stream discharges. San Joaquin River flows west to the trough of the valley and then turns north to form the main drainage for the lower valley portion. Several tributaries, some of large size, join the San Joaquin from the east, but the meager run-off of the west side rarely reaches the river. The streams from the Sierra have generally built deltas into the valley, over which they can be distributed for irrigation without serious difficulties, Kings River being particularly easy to divert. This feature has been of material assistance in the development of irrigation.

San Joaquin Valley has also been prominent in the water-right litigation of the State, the riparian doctrine being first defined in the case of *Lux* vs. *Haggin*, on the Kern River. The large cost and unsatisfactory outcome of the various lawsuits have caused many combinations of interests and compromises over water rights to be made outside of the courts. Much of the water used is now diverted under such compromise divisions, which have proved of more value and stability than any procurable in the courts alone. These conditions have also made it easier for single owners to obtain control of large areas.

KERN RIVER AREAS.

The Kern River area includes the main portions of Kern River delta and the valley and plains lands lying across the southern end of the valley, containing 390,000 acres of valley and 228,000 acres of plains, of which 115,500 and 570 acres, respectively, are reported as irrigated, although the irrigated acreage varies in different years, depending on

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the discharge of the river. The area is dependent almost entirely for its surface water supply upon the flow of Kern River. The mean annual rainfall, 4.81 inches at Bakersfield, is the lowest, and the mean annual temperature, 66.4 degrees, the highest of any portion of the valley. The area served by the canals lies mainly on the delta which Kern River has built into the valley and north of this delta. Canals now built cover 300,000 acres, of which a total of 176,000 acres are reported irrigated at present, including the areas along Buena Vista Slough and in the valley north of the delta. Considerable information regarding the Kern River and its canals has been published.[1] Records of stream flow cover twenty-three years, the measuring station being at what is known as the first point of measurement, about 5 miles above Bakersfield.[2] The mean annual discharge for the full period has been 1,060 cubic feet per second, equal to 770,000 acre-feet per year, the maximum annual discharge being approximately 2.5 times the mean, and the three years with lowest discharge occurring in succession, 1898 to 1900, averaging 40 per cent of the mean annual flow. The highest stages occur in May and June, the lowest from Steptember to November.

Except Kern River, there are no surface sources of water supply of importance in this area. The other streams have no high mountain drainage areas and as a result have an irregular and small run-off. Discharge records have been published for Caliente Creek,[3] the mean annual run-off for six years being estimated as 138,000 acre-feet. Around the southern end of the valley are a few very small streams. such as El Tejon and San Emidio creeks, which yield a small run-off. San Emidio Creek now being used to irrigate about 100 acres of oranges and deciduous fruits.

The pumping of underground water is being rapidly extended and in many localities gives promise of supplying quite large areas. An area lying around and east of Buena Vista Lake has artesian flow, 112 wells measured in 1905 yielding a total of 70 to 75 cubic feet per second.[4] In 1909, 2,097 acres were irrigated from flowing wells in Kern County. Deep seepage in the Kern River delta is considered to be the origin of this supply. The 114 pumping plants reported by the last census in Kern County irrigated 4,290 acres in 1909. The area reported irrigated from wells in 1912 is 12,240 acres, the construction of electric power lines having stimulated the use of this type of power. The lift varies with the location, being about 30 feet or less in the Kern River delta. The plains area which extends in a broad belt around the southern end of the valley must depend for any future water supply upon pumping from wells or storage of the flow of minor creeks. The pumping of underground water with lifts of from 130 to 230 feet is

[1]U. S. Dept. Agr., Office Expt. Stas. Buls. 237 and 239; U. S. Geol. Survey, Water Supply and Irrig. Papers Nos. 17, 46, and 222; U. S. Dept. Agr., Bureau of Soils, Soil Survey of Bakersfield Area.

[2]1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, State Engineer, 1886; 1894-1910, U. S. Geol. Survey Water Supply Paper No. 299.

[3]California Engineering Dept., 1878-84, Physical Data and Statistics, Wm. Ham. Hall, 1886.

[4]U. S. Geol. Survey Water Supply Paper No. 222

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being practiced near Edison, citrus trees having been planted there. The greater portion of this plains area has not been prospected for pumping supplies, so that any estimate of the extent to which these can be developed for irrigation is impossible. Owing to the small catchment areas and the low rainfall, only limited supplies can be expected, particularly across the southern end of the valley. On the eastern portion nearer Kern River it is possible that considerable quantities can be secured without permanently lowering the ground water, as, where the soil and temperature conditions will permit of the growth of the high-valued citrus fruits, higher lifts will become feasible.

Kern River was among the earliest streams used for irrigation in California, and at present utilization of this stream is the most complete of any of the streams in San Joaquin Valley. The legal conflict over water between the upper and lower divertors first brought the riparian doctrine into force in determining water rights in this State, the only working settlement reached, however, being a compromise agreement made outside the courts. The canals are divided into two general groups, the upper consisting of sixteen systems operating under supervision of the Kern County Land Company, and the lower, or Miller & Lux, or Kern Valley Water Company canals, of which storage in Buena Vista Lake is a main feature.[1] The flow of Kern River is measured for division at two points 23 miles apart and an agreement now in force between the two groups provides for division of the water in 6-months periods. The agreement also permits the use of Buena Vista Lake as a reservoir, defines its boundaries, and prohibits storage in Kern Lake. Under this agreement the total flow of the river is quite fully used, diversions continuing throughout the year. Buena Vista Lake has a storage capacity of about 130,000 acre-feet and is used to supply areas to the north. The only water reaching Tulare Lake from Kern River is minor waste from canals flowing to the north or at very high stages through the Goose Lake channel. Kern Island Canal has the prior right to 300 cubic feet per second. This canal and the East Side, Farmers, Stine, Buena Vista, and James canals are the principal canals on the south side of Kern delta, the Beardsley, Calloway, and Pioneer being the chief ones on the north side. The first two cover also lands in the valley outside of the delta proper. All of these are operated under the control of the Kern County Land Company. The Miller & Lux systems consist of an inlet canal into Buena Vista Lake and outlet canals for the irrigation of the Miller & Lux holdings in the valley trough. The various Kern County Land Company systems are reported as irrigating 126,000 acres at present and the Miller & Lux as irrigating 50,000 acres.

Alfalfa and grain are the chief irrigated crops, irrigation in large checks being the rule, the land being owned mainly in extensive holdings where intensive methods are not followed. Much alfalfa is pastured instead of being cut. The soils are variable, sand and peat loams being

[1] U. S. Dept. Agr., Office Expt. Sta. Bul. 239.

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found on the delta, with considerable clay in the southern and western portion. More or less alkali is found throughout, and also considerable unclaimed swamp land. The water table varies from 2 to 4 feet below the surface near Bakersfield to 12 feet in portions of the delta. The methods and seasonal use of water have been quite largely adapted to the variable flow of the river, water being used whenever obtainable, in some instances pumping also being used to supplement the low flow. The average duty varies from 2.5 to 3 acre-feet per acre.

Future increase in irrigation in the Kern River area will depend on storage in the upper drainage of Kern River and increased pumping from underground sources. Development from summer surface flow can be considered practically at its limit under present methods. A reconnaissance[1] for storage was made by the Geological Survey and feasible sites for the storage of 153,000 acre-feet reported. The extent to which underground sources can be developed can not be determined from present knowledge. A considerable supply should be obtainable in the Kern River delta under the canals, as the seepage loss is large, measurements indicating a loss in the Kern River alone, between the two points of measurement mentioned above, of 20 per cent of the total flow.

Under present conditions of large holdings any changes in the use of the present gravity supply are not probable, as the present methods are adapted to the cheap and quick irrigation of large areas. Division into smaller holdings would result more in increased production than in an increase in the area which would be supplied from Kern River, and development is more probable along the lines of increased crop returns than in increased acreage.

WASCO AREA.

This area extends from the 7th Standard Parallel south to the north line of Kern County, and from the foothills on the east to the lower lands in the valley trough on the west. This includes 368,000 acres of valley land and 81,000 acres of plains, of which 32,500 acres of valley land are irrigated at present, partly from extension of Kern River canals and partly from underground supplies. Poso Creek is the only stream entering this area for which run-off measurements are available, six years' records giving an estimated mean annual run-off of 92,000 acre-feet.[2] This run-off is torrential and irregular, storage being necessary for its use. The Poso Irrigation District intended to use this stream for the irrigation of 40,000 acres and did considerable construction work, but the project was abandoned. The Calloway and Lerdo canals diverting from Kern River extend to the vicinity of Wasco, alfalfa and grain being the principal crops irrigated. Artesian flow is used to some extent for irrigation in the vicinity of Semitropic, some wells formerly flowing now being pumped, however. Underground

[1] U. S. Geol. Survey Water Supply and Irrig. Paper No. 46.

[2] California Engineering Dept., 1878-84, Physical Data and Statistics, Wm. Ham. Hall, State Engineer, 1886.

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water occurs at depths of from 30 to 40 feet near Wasco, above the canals the increase in depths becoming about 100 feet at Famosa and being too great under the plains land to justify pumping for any crops except citrus fruits, which as yet have not been grown here. The underground water under the valley should be capable of supplying several times the present area and development is rapidly taking place, both individually and under the colony system. Owing to the small run-off the locally tributary drainage area, large underground supplies are not to be expected under most of the plains area here, although some pumping for citrus fruits may eventually be done. The existing canals from Kern River at present are constructed to cover more land than they can supply, and increase in the irrigated area will depend almost entirely upon the use of underground supplies, chiefly in the lower valley lands.

BUENA VISTA SLOUGH AREA.

This area comprises the lower valley lands lying along Buena Vista Slough, extending from Buena Vista Lake to the north line of Kern County, consisting of 116,000 acres, of which 40,000 are reported irrigated. The water supply is obtained from storage in Buena Vista Lake, which has a capacity of 130,000 acre-feet and an approximate area of 25,000 acres. The stored water is used for irrigating wild grass, alfalfa, and grain on the large holdings of Miller & Lux. This area was originally a swamp which has been reclaimed, and owing to the heaviness of the soil, drainage after irrigation is required, the drainage water being used again for the irrigation of other lands, general conditions being similar to those in the lower Kern River delta. Artesian flow is found in the northern part of the area and pumping supplies occur generally at small lifts. The area at present irrigated from surface supplies is not susceptible of much increase, but the underground supplies should make feasible the irrigation of more land. Owing to the heavy soils and slow drainage of this area, any changes in present agricultural methods are not to be expected, particularly under the present large land holdings, and colonization is not probable, as the lands seem best adapted for large-scale crop production.

ANTELOPE PLAINS AREA.

This area includes the valley land lying west of the valley trough in Kern County and includes 304,000 acres of which none are reported irrigated. The Coast Range furnishes practically no run-off to the area, the creeks being very torrential, their small discharge sinking before the valley is reached. Both the quantity and the quality of underground supplies are unsatisfactory, the water obtained being strongly alkaline. The irrigation of this area can not be considered possible under any present standards or knowledge, as any surface water supply would have to come from the east side, where in Kern County the present land under constructed systems exceeds that for which water can be supplied.

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WHITE AND DEER CREEKS AREA.

This area lies on the east side of the valley in southern Tular County, extending west to the lower valley around Tulare Lake, an includes 181,000 acres of valley and 37,000 acres of plains land. Ther are 9,030 acres reported irrigated at present, 7,600 acres being in th valley and 1,430 acres in the plains, underground water being th source for about two thirds of this. White and Deer creeks, the onl tributary streams, have small torrential flow, the discharge of whic measured from 1878 to 1884 by the California Engineering Depart ment,[1] the estimated mean annual run-off being 29,000 acre-feet fo White Creek and 35,000 acre-feet for Deer Creek. The flow of thes streams rarely reaches Tulare Lake and generally fails to reach th San Joaquin Valley as late as July. Underground water is bein developed at many places, flowing wells occurring west of the main lin of the Southern Pacific and pumped supplies at lifts varying from 2 to 30 feet in the lower valley, increasing to from 60 to 120 feet o the plains. Considerable development for citrus fruits is takin place in the higher portions of the valley lands and in the plains

The groves, while largely too young for bearing at present, ar expected to produce as well as those near Porterville. The soil is reddish sandy loam, with hardpan occurring in parts of the plain at depths of 6 feet or less. In the lower valley the groundwate rises close to the surface and much of the soil is impregnated wit alkali. Much of the non-irrigated land is dry-farmed to grain. Th most important canal system is the Deer Creek Consolidated Ditch which irrigates 3,000 acres near Saucelito, alfalfa being the principa crop irrigated. The water is used when available but owing to th small amount and irregular character of the surface flow, no increas in the area at present irrigated by this means is probable, even throug storage. While more expensive because of the higher lifts, irrigatio from pumps in the plains area will be carried to the limit of the wate supply, because of the valuable citrus fruits which can be grow here. As this area is not supplied by any local streams of size th underground supply is more easily exhausted, replenishment comin from the slow general percolation in all directions from the porou delta of the larger streams.[2] While the local additions are probabl similarly small in the lower valley lands, the underground water i considered to be a direct part of the general body underlying th whole valley and therefore not so easily exhausted, although presen use is reducing the artesian flow in some cases and making pumpin necessary on wells formerly flowing. While the limited extent of th water supply will probably prevent the irrigation of more than small part of this area, such use of underground supplies as may b feasible will allow a material increase in the area at present irrigated

[1] California Engineering Dept., 1878-84. Physical Data and Statistics, Wm. Ham Hall, State Engineer, 1886.

[2] U. S. Geol. Survey Water Supply Paper No. 222.

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PORTERVILLE, OR TULE RIVER AREA.

This area includes the land adjacent to Tule River and that traversed by its sloughs, extending from the White and Deer creeks area on the south to the Kaweah River area on the north. It includes 162,000 acres of valley and 37,500 acres of plains, of which 38,010 and 11,710 acres, respectively, are reported irrigated, although the area watered varies from year to year with the supply available. In years of high stream-flow, 14,000 acres additional are irrigated near Tulare Lake. In the plains of this and the Kaweah areas are included some land which, while it might properly be classed with the foothills, yet is not sufficient in total area to make its separate treatment advisable. This foothill land consists of a narrow strip now generally planted to citrus fruits, extending for a short distance up the steep slopes, and of a few small coves of cultivable land which are more or less separate from the main valley.

Two discharge records have been kept on the Tule River, which is the only stream of importance in this area.[1] The later records of the Geological Survey at their station above the mouth of South Fork show a mean annual run-off of 204 cubic feet per second, equivalent to 148,000 acre-feet per year. South Fork furnishes but little water during the summer season. The discharge in the maximum year of record was 2.3 times that of the mean, and in two years in succession the run-off was slightly less than one half the mean. The largest flow occurs from March to May, August and September being the minimum months. It is only during flood periods in the spring that any water reaches Tulare Lake. Not considering waste, the natural flow is as fully utilized already as is practicable, and any increase in acreage must come from storage, opportunities for which are not considered favorable. Underground supplies have been largely developed in the upper portions where valuable citrus fruits can be grown, the lifts being from 75 to 100 feet and more. The extent to which the underground supplies can be drawn upon in these higher portions is uncertain, some lowering of the ground water level having already been observed in places. Artesian flow can be obtained in the lower portions of the Tule River delta. The pumping lifts in the intermediate lands are comparatively low and the quantities of water available are greater than on the higher areas.

Irrigation from the Tule River began in 1859 and development has been characterized by the building of many canals, some of considerable length, others being short openings in the stream-bank for flooding purposes. The total area covered is approximately 200,000 acres, the systems of the Tule River and Tipton irrigation districts having been abandoned because of difficulties over water rights and the building of other canals for larger areas than could be supplied. There has

[1] 1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, State Engineer, 1886; 1901-10, U. S. Geol. Survey Water Supply Paper No. 299.

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been much litigation over water rights without reaching any gener settlement. In 1909, 37 of the lower riparian owners secured the rig to 400 cubic feet per second during the twenty-two days from Mar 19th to April 10th as against all the upper ditches.[1] This amount considered sufficient because the valley land along the river is ordinari irrigated but once each season. The alfalfa on the upper lands irrigated two or three times as water is available. On the plains a higher valley lands where frost conditions permit, as in the vicini of Porterville, citrus fruits are the predominating crop, the ear ripening of oranges giving them an advantage in the market. T soils in this portion vary from clay loams to clay adobe.[2]

Future development in this area will be by increased returns fro the use of surface flow by reduction of present losses in canals, and increasing the area irrigated from wells, which source may be made supply several times the acreage in the valley lands at present receivi water from underground sources. Changes from the present fora crops to the more profitable ones also are probable in the lower portio of this area.

KAWEAH RIVER AREA.

The Kaweah River area lies between the Tule and Kings River are and includes the lands tributary to the Kaweah River, extending we to the lower lands irrigated from underground sources around Tula Lake. There are 342,000 acres of valley land and 37,000 acres of plai of which 117,550 and 7,130 acres, respectively, are reported irrigate The area irrigated in the lower lands varies quite largely from year year, depending on the available water supply. There are 20,000 ac additional irrigated from the Kaweah River by the Settlers Ditch the lower Kings River area.

Kaweah River is characterized by the several channels into which tends to divide after reaching the valley. Except as controlled for ir gation purposes, these channels are shifting and the maintenance diversions has required much work and expense. Stream records f two periods are available, 1878–84 by the California Engineeri Department and 1903–10 by the United States Geological Survey,[3] t average of all records giving a mean annual run-off of 736 cubic fe per second, equal to 533,000 acre-feet per year. In the maximum ye the discharge was approximately twice and in the minimum year o half of the mean. May and June are usually the months of high flow, averaging about 1,900 cubic feet per second, during September November the discharge often falling below a monthly mean of 1 cubic feet per second. During the high stages excess water reach Tulare Lake; during low stages all the flow not diverted by the upp canals sinks in the river bed. The natural flow is now as fully divert for direct use as can be expected. The storage of flood waters wou

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 239.
[2] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Porterville Area.
[3] California Engineering Dept., Physical Data and Statistics, 1886; U. S. Geol. S vey, Water Supply Paper No. 299.

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add to the low flow and increase both the acreage and value of the crops raised. Although no data regarding possible storage sites are available, some development should be practicable.

Irrigation with water from underground sources is increasing. Artesian strata underlie the lower portions of the delta, while in the higher valley and plains the lift varies from 50 to 100 feet. Seepage from Kaweah River and its canals furnishes the underground supply, which occurs in the largest quantities near the river and in the least quantities in the portions of the plains more distant from the large streams. In the southern part of the plains in this area, near Lindsay, the groundwater level fluctuates with the seasonal use due to the many plants operating. Much of the land in the Kaweah delta, around Visalia, receives water by subirrigation. In some cases the rise of ground water has been sufficient to injure crops, but no comprehensive plans for drainage have as yet received consideration. Irrigation from the Kaweah River began in 1853. The floods of 1861–62 made material changes in the main channels and were the beginning of complications which have resulted in many conflicts, it being estimated that $400,000 has been spent in litigation.[1] There are two associations of canal companies composed of those diverting from the St. Johns River and Kaweah River channels, respectively, which operate under an agreement as to the division of the water. When the flow exceeds 80 cubic feet per second it is divided between the two channels; when less than this amount it all passes into the Kaweah channel.

Sixty-two canals divert from the Kaweah River, although only 107,000 acres of the 203,000 acres covered by constructed systems are irrigated. Practically all are managed coöperatively, the individuals receiving water in proportion to the stock held in the ditch companies. Tulare Irrigation District includes 37,400 acres, of which about 12,000 acres are usually irrigated, the area varying in different years with the water supply available. The history of this district, which was organized in 1889, has consisted largely of dissension and difficulties with the holders of the $500,000 of district bonds. These were purchased for $273,000 in 1903, a single levy of 36 per cent of the assessed valuation being made for the purpose. Conditions are improving and irrigation can be expected to increase.

In the lower lands alfalfa and pasturage are the crops of largest acreage, dairying being an important industry. In the vicinity of Exeter and Lindsay, in the so-called thermal belt, extending along the higher valley and plains lands, citrus fruits are successfully grown. The soils and land values of this area are similar to those in the Porterville, or Tule River, area. Any increase in the irrigated areas will come from a better use of present diversions through improvements in canal systems and administration, the rise of ground water in some localities indicating over use. Increase in pumping in the lower delta lands should serve the twofold purpose of increasing the irrigated area as

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 239.

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well as tending to partially relieve the poor drainage conditions. The use of storage, if feasible, and extension of the use of underground supplies will permit of the production of higher valued crops requiring late season irrigation, which at present cannot be sure of securing water when needed. While the sub-surface resources may be at present developed quite fully in the higher areas, much opportunity for their use in the valley lands yet remains and it is here that the largest increase in irrigated acreage is to be expected.

TULARE LAKE AREA.

The Tulare Lake area consists of the lower land lying on the south and west of Tulare Lake in Kings and Tulare counties, watered partially by Kaweah and Tule river water but more largely by underground supplies. There are 240,000 acres of agricultural land exclusive of the present area of Tulare Lake, of which 58,420 acres are reported irrigated, 14,000 being supplied from the Tule River during times of flood flow and 44,420 from artesian flow and pumped wells. The area of the lake as partially controlled by levees at present is 133,000 acres. When at an elevation of 220 feet, at which stage it overflows to the north, the area is approximately 500,000 acres. All unused flow of the drainage area from Kings River south, excepting the part of Kings River discharge which flows directly to the San Joaquin River through the sloughs to the north, reaches Tulare Lake. Since the settlement of the valley the lake surface has varied from overflow stage to entirely dry, the last overflow being caused by the floods of 1861-62. Since then it has fluctuated, gradually declining until in the summer of 1905 it was entirely dry. As the area of the lake decreased, the exposed land was settled and farmed to grain, practically the whole area at one time being cultivated. The high run-off of the streams in 1906, the discharge being twice the mean, caused the lake to rise, submerging 300 square miles including much grain and improvements. The lake continued to rise until 1909 and has since been slowly receding. Increase in diversions for irrigation will prevent the flow of water to the lake in any but small quantities except in years of excess stream flow, such as 1906. The recurrence of such stream conditions can be expected more or less periodically. Such years as this will always cause the accumulation of much water in the lake bed, unless provision is made in the Kings River channels for diverting these flood water to the north to San Joaquin River, which is considered to be physically feasible. The cutting of the Kings River delta and the draining of Tulare Lake to the north for the irrigation of lands on the west side of the San Joaquin Valley was at one time contemplated, but the uncertainty of the supply has caused the abandonment of this project. At present much of the original lake bed is cultivated, the present lake being partially restrained by levees.

The present irrigated areas are supplies most largely from ground water resources. Development has been largely under the colony system, the wells being constructed for the whole colony and the land

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then sold in small tracts. Both artesian wells 900 to 1,600 feet deep which yield from 5 to 40 miner's inches of water each[1] and shallow wells which are pumped are used. Alfalfa, grain, and vegetables are the principal crops, a considerable acreage having been used for sugar beets. The underground waters here are part of the general valley body and should be capable of much use without exhaustion, although some wells formerly flowing now require pumping. Irrigation here is independent of the variations of stream flow, water being available as needed, permitting the more intensive and profitable cultivation. Development has taken place most largely along the eastern portion of the area where transportation facilities are better. Further increase here as well as in the southern part of Kings County is to be expected.

VALLEY LANDS WEST OF TULARE LAKE.

These lands totaling 119,000 acres comprise Kettleman Plains, McLures Valley, and the west-side areas in southwestern Kings County. Like the west-side areas farther to the south they are practically devoid of a water supply, the surface run-off of the tributary drainage area being negligible in amount and the underground supplies being, so far as is known, of great depth, small quantity, and doubtful quality. Any irrigation, except possible along the margin of Tulare Lake from artesian supplies, or any agricultural use of this area cannot be considered practicable by any present standards or knowledge.

KINGS RIVER AREAS.

In the agricultural area dependent mainly upon Kings River for a water supply, extending from Kaweah and Tulare Lake areas on the south to San Joaquin River and San Joaquin and Kings River Canal on the north, there are a total of 1,936,000 acres of valley and 83,500 acres of east-side plains, of which 704,140 and 2,350 acres, respectively, are reported irrigated. Of the irrigated area 628,780 acres are supplied by gravity canals from Kings River, 34,100 acres by pumping from underground supplies, and the remainder from San Joaquin or west-side canals. For convenience of discussion the total area is later separated into six divisions.

Kings River has built a delta which with that of Los Gatos Creek on the west side reaches across the trough of the San Joaquin Valley forming a barrier over which, in recent times, the streams to the south have rarely been able to flow. The ease with which the river can be diverted and carried to various delta lands has led to a larger irrigation development than that from any other single stream in the State. Much of description and investigation has been published concerning the various phases of this development.[2]

Kings River is one of the three largest streams in San Joaquin Valley, the twenty-one years of published records showing a mean annual run-off

[1] U. S. Geol. Survey Water Supply Paper No. 222.

[2] U. S. Dept. Agr., Office Expt. Stas., Buls. 100, 217, 237, and 239; U. S. Geol. Survey, Water Supply and Irrig. Papers Nos. 18, 52, and 222; U. S. Dept. Agr., Bureau of Soils, Soil Surveys of Fresno and Hanford areas.

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of 2,650 cubic feet per second, equal to 1,920,000 acre-feet per yea
May and June are the months of highest flow, averaging about 8,0
cubic feet per second. The mean discharge in September falls to 4
cubic feet per second. The annual variations in discharge are simil
to other San Joaquin Valley streams, the maximum annual dischar
being twice and the minimum annual discharge a little less than one ha
of the mean. During high stages the flow of the river divides, pa
following the main channels to Tulare Lake and part the sloughs to t
north, finally reaching San Joaquin River. In years of low or mediu
flow but little water is unused, but in years of large flow a considerab
amount is undiverted.

Irrigation first began from Kings River in the early sixties and h
increased until at present 628,780 acres are reported irrigated out of
total area under constructed systems of 800,000 acres. Much litigati
has arisen over water rights, present diversions being made chie
under agreements among the larger companies which have been embodi
in court decrees, the tendency of continued litigation having been
cause combinations of canal systems and compromises as to water use

The natural flow of Kings River is diverted directly to as great
extent as is practicable. Any large additional canals under prese
conditions would receive water for too short a period during hi
stages for their construction to be feasible, unless the water supp
can be supplemented from storage or pumping, and except as it
found feasible to use water in spring only. The rise of ground water
causing the use of less water in many cases, thus allowing addition
areas to be served, although the difficulties with drainage tend
balance this advantage, so that no extensive increase in area can
anticipated from the direct use of natural flow. The most favorab
opportunities for increase are by pumping from the undergrou
waters and by the storage of the unused flood flow. But little go
land remains unirrigated on the east side of the valley and any lar
new supplies which are developed will probably be carried to the we
side. The possibilities for storage of flood flows have been inves
gated and reservoir sites with a total capacity of 340,000 acre-fe
reported,[2] a water supply being considered available for the vario
reservoirs. By increasing the height of the proposed Pine Flat Rese
voir to 270 feet, it is estimated that a storage capacity of 400,000 ac
feet can be obtained at practicable costs. The construction of su
storage would permit either an increase in irrigated area, or furni
late season water to present areas, thus increasing the yield from alfal
and other crops. Any attempt to store flood waters in the Sierra und
present water-right conditions except by agreements with present can
systems would probably be impracticable, because of the litigati
which it would be liable to provoke.

The development and use of underground water will be the sour

[1] 1878-84. California Engineering Dept., Physical Data and Statistics. Wm. Ha
Hall, State Engineer, 1886; 1895-1910, U. S. Geol. Survey Water Supply Paper No. 2
[2] U. S. Geol. Survey Water Supply and Irrig. Paper No. 58.

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of the greatest increase in the area irrigated from Kings River. Continued irrigation has raised the groundwater until it has rendered much land unfit for cultivation, so that the removal of this water for use would be of twofold advantage. The quantity which it will be practicable to develop cannot be estimated until it has been at least partially tested. In drainage investigations which were made in 1906[1] it was estimated that the annual removal of three quarters of a foot in depth of water over an area of 200,000 acres in the vicinity of Fresno would relieve the harmful conditions at that time. Considering the delta as a whole it is probable that 300,000[2] acre-feet or more will be annually available by pumping, or sufficient for the irrigation of 120,000 acres or over at a duty of 2.5 acre-feet per acre. The use of this drainage water on the west-side valley has been projected, although it is not known how much of this ground water it will be practicable to recover. The irrigation census of 1909 reported 888 pumping plants in Fresno County and these are being increased rapidly, the largest number being in the vicinity of Fresno. Artesian flow can be secured in the lower valley lands extending from the Kings River to the San Joaquin. In general, ground water can be secured at lifts of 30 feet or less, in some portions of the lower delta water occurring within reach of plant roots, which condition has caused much damage from alkali. The pumping of ground water would be of general benefit to the lands now affected by high water-table, and is the more probable means by which any future development will be undertaken. While at present the use of water during short periods of large supply may be excessive, the general average amount applied is not likely to be materially reduced, the mean annual flow of Kings River when divided by the area at present irrigated indicating a mean gross duty of about 3 acre-feet per acre, and in years of low discharge much less water is available. With a general and more definite determination of present rights the use of any excess flow either directly or by storage will become practicable.

ALTA AREA.

This area includes Alta Irrigation District, with its adjacent valley and plains lying north of the Kaweah area and south of Kings River. There are 147,000 acres of valley land and 39,000 acres of plains, of which 93,950 and 1,130 acres, respectively, are reported irrigated, Alta Irrigation District including 130,000 acres of the valley land, of which 90,000 acres were irrigated in 1912. The remaining valley land lies in small pieces along Kings River bottoms and also above the Alta canals. There are 2,200 acres irrigated from Kings River along the river bottom outside of Alta Irrigation District, the remaining 1,760 acres being irrigated from pumps. Alta District purchased and extended the canals and rights of the Seventy-Six Land and Water Company, the water rights of which call for 800 cubic feet per second. However, this is subject to

[1] U. S. Dept. Agr., Office Expt. Stas. Bul. 217—Drainage of Irrigated Lands in San Joaquin Valley, issued 1909.

[2] U. S. Geol. Survey Water Supply and Irrig. Paper No. 58.

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other priorities, so that their supply usually ceases during July, som water being also received in October and November by agreement wit earlier rights. Conditions vary from small, prosperous holdings i vineyards and fruit, as around Reedley and Dinuba, to lands needin drainage which furnish pasturage only, as around Traver. The distric encountered many legal difficulties both as to water rights and distric bonds, but these matters have now been arranged and the district affair are in an improved condition. The use of water is excessive in man cases and the losses through seepage in the canal are high. An increas in the irrigated area with the present water supply should be feasibl as more of the land is placed in the better paying crops and more carefu methods of irrigation are practiced. Underground water at shallo depths underlies the valley lands and can be pumped during the late season to supplement the canal water. Some of the lower parts of th district are seriously in need of drainage and by remedying this continuation of the present rate of progress is to be expected. Citru fruits are successfully grown on the higher valley and the plains land water being usually obtained by pumping from the canals or fro wells, the lifts from the latter generally varying from 50 to 80 fee Further increase in the irrigated area should be feasible in the plain lands, although the amount of water which the underground supplie can furnish without depletion may be limited in the more unfavorabl situated portions.

HANFORD AREA.

Lying below the Alta area on the south side of Kings River in King County and extending to the trough of the valley and to Tulare Lak one the west and south is an area of 226,000 acres, of which 159,36 acres are reported irrigated, the areas irrigated under the differen canal systems being reported as follows: Peoples Ditch, 60,000 acres Last Chance Canal, 35,000 acres; Lemoore Canal and Irrigation Com pany Canal, 30,000 acres; Lakeside Canal, 20,000 acres; Empire Canal 12,000 acres; pumping from wells, 2,360 acres. All these canals obtai their supply from Kings River, except Lakeside Canal, which receive Kaweah River flood water. Much of this area is subirrigated and i many places on the lower lands the high ground-water level has caused much damage from alkali and water-logging. About one half of th acreage is in alfalfa and one half in trees and vines, the lower area being used most largely for the forage crops and the higher lands in th vicinity of Hanford for the fruit crops. The soils are sand and sandy loams.[1] The canal systems are owned coöperatively, the amount o water received and the charges paid being proportioned to the amoun of stock owned. It is through the lower portions of this land that th waste and flood waters of Kings River reach Tulare Lake. Artesia and pumping supplies underlie the areas at present unirrigated, an with more economic use of the flow of the canals, a water supply shoul be available for that part of the remaining unirrigated lands whos

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Hanford Area.

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soil and drainage conditions make improvement feasible. With ground water so close to the surface, its control is as important as irrigation.

FRESNO AREA.

The largest section irrigated from Kings River, which is generally referred to as the Fresno plains, lies between Kings and San Joaquin rivers, extending from the foothills on the east to the lower valleys and slough areas on the west. There are a total of 535,000 acres of valley land and 44,500 acres of plains, with 325,400 and 1,220 acres, respectively, reported irrigated. The Fresno Canal and Irrigation Company and the Consolidated Canal Company, which are under one management and form the largest single irrigation enterprise in the State, include 207,000 and 90,000 acres, respectively, of the area reported as irrigated. Water rights are issued by these companies on the basis of 1 cubic foot per second for each 160 acres, each right being for a proportional part of the flow in the canal and fixed on some specific tract of land. Second-class water rights have also been sold to waters possessed by the company in excess of the original appropriations. There is an annual rental charge of 62½ cents per acre under the Fresno system and 75 cents under the Consolidated, only water-right contract holders being permitted to receive water. Emigrant Ditch irrigates about 2,000 acres in this area, and the remaining 26,400 acres are supplied by pumps. The excessive use of water has caused the ground water to rise sufficiently high with its attendant alkali in some cases to kill trees and vines and much of the western part of this area is in immediate need of drainage. The soils are generally sandy, both the red or granitic and the white or ash soils occurring.[1] Hardpan is found at varying depths, being less than 3 feet below the surface on portions of the plains and higher valley lands.

This district is particularly noted for its raisins, raisin grapes being the predominating product, and table and wine grapes, deciduous fruits, alfalfa, and pasture the other principal crops, the alkali and lower lands being largely used for pasture.

The area is quite completely developed at present, many pumping plants supplying water to supplement the canal water in the low water season, as well as to entirely supply lands which receive no canal water. Any large increase in irrigated area by new projects is not to be expected, as the remaining unirrigated lands lie chiefly in the lower valley where soil conditions are not as favorable as on the unirrigated lands of the west side, where any large future water supply is most likely to be used. The removal of ground water for use elsewhere or for drainage purposes alone would be a material improvement for large areas, and is the most probable course of development. Higher canals covering the plains land are not probable and it would seem that future irrigation there as at present will mostly be confined to the use of the very small local run-off and to water pumped for citrus fruit, the extent of the underground supplies under the higher portions being largely untested.

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Fresno Area.

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MURPHY SLOUGH AREA.

Lying north of Kings River in the lower valley and along the slough leading to San Joaquin River is an area of 135,000 acres, of which 77,840 acres are irrigated as follows: Laguna de Tache canals, 30,00 acres; various canals of Summit Lake Investment Company, 14,88 acres; Crescent Canal, 11,840 acres; Stinson Canal, 10,080 acres; Mil race Ditch, 3,840 acres; Liberty Canal, 4,640 acres; and Reed Cana 2,560 acres. While some of these systems are among the oldest divertin water from Kings River and the areas irrigated have not change materially for some years, the area irrigated is now being increased b the Summit Lake Investment Company, which is engaged in reclaimin land north of Summit Lake in the vicinity of Lanare. Alfalfa is th most important crop in this section, stock raising and dairying bein largely followed. This section consists largely of the lower valle lands, and the high ground water and lack of adequate drainage hav caused much damage from water-logging and alkali and prevente the successful raising of trees and vines in some portions of the are With care in the use of water and drainage where practicable, a con siderable increase in the irrigated area should be feasible both fro canals and from underground sources, although it is not to be expecte that the intensive and highly developed agriculture such as is foun around Fresno will become general here.

JAMESAN AREA.

Lying along the valley trough north of the Murphy Slough area an extending to the lands irrigated from San Joaquin River canals is a area of 130,000 acres, of which 43,000 acres are reported irrigate 29,000 acres of grazing land being flooded from Fresno Slough whe Kings River is high. Of the land irrigated, 10,500 acres are in Tra quillity Colony, the James ranch including the flooded grazing lan only. A water supply for 1,300 acres on the Borland ranch and fo 4,500 in Tranquillity Colony is obtained by pumping from Fresn Slough. One thousand acres on the Mowrey ranch receive water directl from San Joaquin River through Herminghaus Ditch. The wate pumped from Fresno Slough is in part backwater from San Joaqui River and in part flood and waste water from Kings River, dependin on the relative stages of the two streams. General conditions are simila to those in the Murphy Slough area, alfalfa, corn, grain, and pastu being the principal crops. Further development of the portions o this area where soil and drainage conditions warrant should be fea ible, the land lying so as to be susceptible of irrigation from eith Kings or San Joaquin River. With the exception of the Tranquillit Colony, the land is held in large tracts mainly by the James and th Miller & Lux interests. Pumping plants obtaining water from wel are used to irrigate 1,220 acres near Mendota, the deeper and partiall artesian supplies being used.

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WEST-SIDE LANDS NORTH OF TULARE LAKE.

Lying north of Tulare Lake and extending through Fresno County between the lower valley lands and the edge of the west-side hills is a broad strip of arid land containing 763,000 acres, of which only 4,580 acres are irrigated by the local west-side streams. The valley land on the west side of San Joaquin Valley is not as broad as that on the east, the larger amounts of débris brought down by the eastern streams having carried the valley trough west of the center of the valley. But little development has taken place on this side because of the lack of an adequate water supply. The local streams rise in the generally low and barren Coast Range, the precipitation on which is small and the run-off torrential and unreliable. The ground water underlying the area is generally too alkaline for either plant or stock use, besides occurring at great depth and being of small quantity. All agricultural conditions except water supply are very favorable, and several methods of obtaining water have been proposed. This area comprises the largest body of these west-side lands and lies above the reach of gravity canals which might be carried across Kings River delta. Kings River must be depended upon for any water supply of considerable quantity, although the San Joaquin River might be available for a portion of the northern end. Los Gatos and other small creeks carry some irregular flood flow which it may be feasible to store and use through quick flooding for the irrigation of some small areas, as is being done by the Belmore Land and Water Company on Panoche Creek, where 4,000 acres are being irrigated. The total area, however, which can be developed must be small. The use of underground water as at present known cannot be relied upon. As shown in the discussion of Kings River the surface flow of this stream is quite largely diverted, the only opportunities for obtaining a supply from Kings River being either by using Sierra storage or by the pumping of underground water in the Kings River delta and pumping again from the valley trough. The quantity of these underground waters which can be developed cannot be estimated closely. Kings River delta is underlaid at small depths with a comparatively abundant supply of underground water and it may be feasible to recover much of this. It is not improbable that one quarter of the flow of Kings River reaches this underground reservoir, although there is no definite basis available on which an estimate of this can be made. One quarter of the total mean flow would give nearly 500,000 acre-feet annually, or sufficient for 200,000 acres at a duty of 2.5 acre-feet per acre. The use of this water would require pumping from scattered wells on the east side, conveying to the valley trough and raising to the points of use on the west-side lands, so that the recovery of over one half to two thirds of this is all that may be expected. Investigations of the possibilities of irrigating the lower portion of these lands by these means have been made and the construction of systems of greater or less extent is probable. The quality of the soil, freedom from underlying hardpan, even slopes, and climatic conditions would make this land

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very attractive if a water supply can be provided, and these agricultural advantages are considered to be sufficient to make feasible the additional cost of conveying the water across the valley trough. The elevation of the highest point in the valley between Kings River and Los Gatos Creek delta fans is approximately 210 feet. Lying between the limit of gravity canals from the valley summit and the 250-foot contour are over 200,000 acres, while probably 150,000 acres more lie below the 300-foot contour. Owing to the length of canals necessary to reach all of this land, the actual lifts required would be in excess of that indicated above, but there should be sufficient land at a feasible lift to utilize whatever water supplies may be secured. The remaining and larger part of this area must be considered as non-irrigable by any present standards of cost and water supply, the highest portion being over 150 feet above the center of the valley and any water supply which may be secured will not be sufficient for even the lower areas.

AREAS WEST OF SAN JOAQUIN RIVER.

Lying west of the San Joaquin River largely below the San Joaquin and Kings River Canal and extending north to Tracy is an area of valley land of varying width and characteristics which is dependent practically wholly upon San Joaquin River for a water supply. The east side of the valley, while of much larger extent, is generally well supplied by the local Sierra streams, and with the exception of Madera County and the low valley lands is more easily irrigated by these tributaries. Unlike the west-side lands farther south, in this area gravity diversions can command the greater part of the area, although on the more northern lands it is probably more practicable to pump from the river than to convey the water in the long gravity canals which would be required. The local west-side streams are of small torrential flow and while they may be quite fully utilized through storage they can never supply more than a negligible part of the whole. San Joaquin River has been used more for the irrigation of alfalfa, grain, and pasture land and less for the higher valued orchard and vineyard products than the other streams. The high banks which border the river as it flows west to the trough of the valley have prevented its early diversion there and the ease with which it can be carried to the generally flat areas in the lower valley floor has made its use on these the more natural development. The owners of large holdings of Spanish-grant and swamp-lands have so largely controlled riparian rights as largely to control the flow of the river. Records of the discharge of the San Joaquin covering sixteen years are available.[1] These measurements were made at the edge of the foothills above any diversions. The mean annual flow for the full period has been 2,850 cubic feet per second, equivalent to 2,060,000 acre-feet per year. May and June are the months of greatest flow, the mean flow for June being 8,500 cubic feet per second. The flow decreases to an average of approxi-

[1] 1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, 1886; 1895-1901 and 1907-1910, U. S. Geol. Survey Water Supply Paper No. 299.

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mately 500 cubic feet per second from September to November. The total annual run-off in the year of maximum discharge of record was a little over one and one half times and in the year of minimum discharge a little less than one half of that of the mean annual discharge. Under present conditions the flow of San Joaquin River in its upper valley portions is quite fully diverted. Any further extensive diversions without storage could obtain water, if at all, for too short periods during high flow to enable crops requiring more than flooding to be certain of receiving sufficient water. The dependable part of the flow is now used quite fully for various crops but mainly for alfalfa and grain. That portion of the flood flow which is of short duration is used for flooding pasture lands either in natural overflow areas along the bottoms or by artificial methods. Any material increase in amount or value of the returns from the use of San Joaquin River water must come from a more economical use of present supplies or from the storage of the flood flow for use on crops of larger return than the pasturage at present irrigated. The acreage under present canals is being gradually increased and further economies will continue this increase. The storage of flood waters is probably physically feasible to a considerable extent, although no actual records of reservoir sites are available. The San Joaquin Light and Power Company is storing some water in the mountains and reservoir sites are reported to exist near Friant if feasible foundations for a dam can be secured. Unless such storage is undertaken by the controlling riparian owners, under the present conditions the legal difficulties will probably be greater than the engineering ones. There are areas lying above the flood limits and also above present irrigation, both on the west side and in Madera County, which can be covered by canals at a feasible cost if an assured water supply can be provided, and the use of the San Joaquin is as yet much short of its possibilities both in acreage and in value of crop returns.

FIREBAUGH TO CROWS LANDING.

Extending from near Firebaugh to Crows Landing is an area consisting of the lands under the San Joaquin and Kings River Canal and the higher valley lands north of Fresno County, which includes 367,000 acres of valley land, of which 127,250 acres are irrigated. Also 40,000 acres of uncropped grazing land are flooded from branches of San Joaquin and Kings River Canal. San Joaquin and Kings River Canal, 72 miles long, with a total diverting capacity of about 1,550 cubic feet per second, is the largest of the canals diverting water from San Joaquin River. The total area between the canal and the river is 333,000 acres, of which approximately 50,000 acres consists of the lower-lying lands subject to more or less overflow, although this area may be increased in seasons of abnormally high water. There were 125,100 acres irrigated in 1912 under San Joaquin River and Kings River Canal, including both small holdings and lands of Miller & Lux, water delivered by the canal company being charged for on an annual rental basis.

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The slough and overflow areas lie in the northern and eastern parts of the area. Waste water from the canal and flood waters from the river are used to flood the native grasses, large checks having been built which enable extensive areas to be irrigated quickly. Owing to their small elevation above the river and liability to flood, this use is perhaps the most feasible one for these lands, and the crop limitations due to these conditions will probably prevent any more intensive use being made of a large portion of this area as higher and more easily reclaimed lands are available elsewhere for all the dependable water supply which can be developed. The valley lands not subject to overflow and below San Joaquin and Kings River Canal consist mainly of Miller & Lux holdings and of colonies which have been sold by them. Alfalfa and other forage crops predominate, stock feeding and dairying being the main industries. The irrigated lands below the canal are generally flat, with clay loam soils predominating, which become heavier as the river is approached, considerable alkali also being found in the lower portions. Alkali reclamation is being successfully accomplished where a water supply for such purpose can be procured. Although the late-season water supply is less than desired, good returns are secured and the irrigated area is being continually extended by more economical use of the canal water.

Lying above the canal is a strip of valley land of 64,000 acres, varying in width from practically nothing west of Los Banos to strips from 3 to 8 miles long on the local creeks. Of this, 2,150 acres are irrigated by creeks and some by pumping from the canals. Much of the area in the northern part is dry-farmed to grain, some adjacent higher rolling land also being used for grain raising. Because of the difficulty of irrigating, even if a water supply were available, it is excluded from the classifications of this report. Practically the whole of these lands lie at elevations of less than 60 feet above the present canal and pumping would be feasible if the water is made available in the canal. Underground water occurs irregularly both as to quantity and quality, and at no place above the canal has a sufficient supply of good quality been found for use in irrigation. Although there are some wells supplying potable water for domestic use, the underlying water is generally deep, alkaline, and scarce. Various small torrential streams, such as Crow, Orestimba, Quinto, Romero, San Luis, Los Banos, and Ortigalita creeks, drain the coast range. Of the 2,150 acres irrigated above the canal from creeks, 650 acres are irrigated during the flood period from Los Banos and San Luis creeks, 1,300 acres from Orestimba Creek, and 200 acres from Crow Creek. A reservoir is being constructed on Quinto Creek from which it is planned to irrigate 700 acres. A site having a capacity of 17,500 acre-feet has been surveyed on Los Banos Creek, which will probably be ultimately developed, as the run-off from over 150 square miles of drainage area, having a rainfall of from 12 to 20 inches, is considered sufficient to fill the reservoir. The use of the various available sources

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will ultimately supply much of this higher area, the possibilities being much more encouraging than for the larger similar areas farther south.

CROWS LANDING TO TRACY.

This area, containing 143,000 acres of valley land, of which 6,200 acres were irrigated in 1912, extends from the lower end of San Joaquin and Kings River Canal to the delta and overflow lands at the northern end of San Joaquin Valley. While an extension of San Joaquin and Kings River Canal would cover some of this area, it is considered more feasible to pump directly from the river. Not only are the construction cost and seepage losses of long canals avoided by pumping, but the water supply available is increased by the excess water of the lower east-side tributaries and waste water from canal systems above. Even with the ultimately large uses of the streams in the San Joaquin Valley, waste and return water will always supply some flow in the lower river channels which will be available for use here. The even slope of the surface and tillable character of the soils makes the preparation of land for irrigation inexpensive. The soils are deep and while variable are generally of a sandy or clay-loam character. The non-irrigated lands are in large holdings. The only large present system is owned by Patterson Colony, which contains about 19,000 acres, of which 6,000 acres were irrigated in 1912. The project has been completed but a short time and the irrigated area is increasing rapidly. The water is pumped in four lifts, the equipment and canals being well planned and permanently constructed.

North of Patterson Colony, between the Southern Pacific Railroad and the river, lying at lifts of less than 40 feet above the river, are approximately 35,000 acres, of which probably 5,000 acres are subject to overflow. The remaining area above the railroad rises from 20 to 40 feet per mile away from the river and greater lifts will cover correspondingly greater areas. Some investigations have been made and the construction of further projects similar to that of the Patterson Colony may be undertaken. By storage, which may be feasible on a small scale, Crow and Orestimba creeks may be able to supply further small areas, but as a whole the development from them is likely to be unimportant. Small pump supplies may be found along the creeks as they enter the valley floor. Underground water, usually said to be of fair quantity, occurs in the lands nearer the river at low lifts. Ground water seems to have an elevation approximately the same as the water in San Joaquin River, the lifts increasing as the foothills are approached. The quantity which can be obtained in the higher areas has not thus far been sufficient for irrigation purposes. Ultimate development in this area will depend on the lifts which may become economical and upon the water supply which can be secured in San Joaquin River. The general agricultural advantages of soil, crops which can be raised, and available markets will in the end force the subdivision of this area into small holdings and full economic development of the water supply.

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TRACY TO BAY POINT.

Lying above the overflow lands of the lower San Joaquin delta on the west side of the valley, there is a generally narrow strip of valley land extending from Tracy to Bay Point, which contains 66,000 acres, of which only a small area is now irrigated. Bay Point is taken as the end of the San Joaquin Valley. The local run-off from the small west-side creeks is similar to that from those farther to the south, being small, irregular, and requiring storage for any valuable use and the total area which they can supply being unimportant in proportion to the whole. All the favorable conditions for irrigation, such as good soil, even slope to surface, available market for products, etc., are present except the water supply. Underground water can be obtained only in the lower areas in the southern part, pumping supplies in some cases becoming brackish in the vicinity of Byron. Fresh water can be pumped from the various channels and sloughs of San Joaquin River as far down as the vicinty of Antioch. High canals from San Joaquin River, while topographically possible, would require too great a length to be really feasible. The elevation varies from 10 to 150 feet, over one half of the area probably lying at lifts of 60 feet or less above the river. The pumping of San Joaquin River water in the southern end of this area has been considered and eventually some development of this character is to be expected as the water supply is proven available. This area is quite largely cultivated at present in deciduous fruits, almonds, and grain, the returns from which would be materially increased by irrigation.

MADERA AREA.

This area covers the valley and plains land in Madera County between San Joaquin River and Chowchilla Creek, with 390,000 acres of valley lands and 112,000 acres of plains, of which 43,000 acres and 40 acres, respectively, of cropped land is reported irrigated. San Joaquin River, whose discharge is discussed under the lower west-side areas, is the principal tributary source of water supply. A considerable portion of the valley land in this area lies so that it can be covered by canals direct from the river; on the higher portions longer canals would be required owing to the depth of the river bed below its banks. Aliso and Blythe canals and Lone Willow and Brown sloughs covered 15,700 acres of cropped land in 1912 in this area. In addition they covered 45,000 acres of low pasture lands by flooding during high water, the area so flooded sometimes being as high as 100,000 acres. Chowchilla and Columbia canals are laterals from Lone Willow Slough. Gravelly Ford Canal is an additional canal that is being constructed for the irrigation of additional higher areas of these lower lands. The Madera Canal and Irrigation Company have about 40,000 acres under its system and irrigated 10,600 acres through it from Fresno River in 1912. Bliss and Sierra Vista canals, from Chowchilla Creek, irrigate 5,000 and 2,375 acres, respectively, and 9,621 acres were reported irrigated in

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Madera County, mostly south and west of Madera, in 1912. The plains areas and non-irrigated valley land are largely dry-farmed to grain, the land being in large holdings. The soils of the area vary,[1] sandy and gravelly loam being the most frequent.

The only streams crossing the area for which discharge records are available are Fresno River and Chowchilla Creek, measurements indicating a mean annual run-off of 121,000 and 110,000 acre-feet, respectively.[2] Both annual and monthly discharges are subject to wide variations. The maximum discharge occurs from February to April, flow generally ceasing by June 1st. Any considerable use of these local torrential streams requires storage as only by this means can their irregular and uncertain flow be made dependable for use on crops requiring water later than May. The Madera Canal and Irrigation Company attempted to store the flood waters of Fresno River but was prevented by a court decison obtained by the lower riparian owners on the grounds that a riparian owner is entitled to have the normal flow of the river reach his lands.[3] This decision at present blocks any development by storage on these streams. On Chowchilla Creek, the proposed Buchanan reservoir site has an estimated capacity of 42,000 acre-feet. It is possible that it is feasible to store sufficient water on these streams to enable a large proportion of their flow to be advantageously used if the legal obstacles of the riparian doctrine can be overcome. The use of underground water has not, until recently, been as extensive in this section generally as in other parts of the valley, although, as already stated, a large acreage is now irrigated by pumping from wells south and west of Madera. According to studies by U. S. Geological Survey, practically everywhere within that part of Madera County west of the Southern Pacific except near the bluffs of San Joaquin River, underground water is available for pumping.[4] As the foothills are approached, depth to ground water increases and the lift necessary in their development increases correspondingly. Although much of this section will remain without an adequate surface water supply except through possible storage on the San Joaquin, it would seem that the use of ground waters will permit of the irrigation of several times the present area now served by pumping plants.

MERCED AREA.

This area includes the part of Merced County south of the Merced River, containing 361,000 acres of valley land and 112,000 acres of plains, of which a total of 41,895 acres are reported irrigated. In addition to this acreage of cropped-land arrigation, East Side Canal, in connection, with flooding from San Joaquin River, flooded 35,500 acres of grazing land, with 10,000 acres flooded from San Joaquin River

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Madera Area.
[2] 1878-84, California Engineering Dept., Physical Data and Statistics. Wm. Ham. Hall, 1886.
[3] U. S. Dept. Agr., Office Expt. Stas. Bul. 239.
[4] U. S. Geol. Survey Water Supply Paper No. 222, p. 44.

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below that canal and 2,000 acres flooded from Blythe Canal, all in 1912. Sometimes this total flooded area reaches about 60,000 acres.

Merced River is the only important stream crossing this area although the San Joaquin forms the western boundary. Discharge records covering sixteen years are available for the Merced,[1] the mean annual flow having been 1,700 cubic feet per second, equivalent to 1,230,000 acre-feet per year. April to June are the months of highest discharge, the mean flow in May, the maximum month, having been 4,600 cubic feet per second. September is usually the minimum month of minimum discharge, the mean discharge for that month being 18 cubic feet per second. The total run-off in the year of maximum discharge of record has been one and three fourths times that in the mean year, and the run-off in the year of minimum discharge 0.4 that of the mean annual discharge.

Merced River, while diverted to a small extent to irrigate the narrow strip of bottom land between Merced Falls and Livingston, is used mainly on lands under the Crocker–Huffman Canal in the vicinity of Merced. There are 220,000 acres reported under the Crocker–Huffman Canal, of which 25,000 acres were irrigated in 1912. During this same season 4,700 acres were irrigated from pumping plants, and about 5,000 acres of pasture at the lower end of the Crocker-Huffman canal are flooded with surplus water from the canal. Water rights have been sold under this canal to cover something over 50,000 acres, this being the area classed as irrigated on the accompanying map. The principal irrigated sections at present are in the vicinity of Merced, Livingston, and Atwater. Water rights are sold for $10 per acre on an agreement to furnish one cubic foot per second for each 160 acres, but there has been little regulation of the quantity of water used and over-use in some cases is causing difficulties from the rising ground water. Except in the colonies, the holdings are generally large. A great variety of crops are grown, including forage, fruit, and truck. The various types of loams predominate in the soils, hardpan occurring at depths of from 5 to 10 feet in many parts.

Local streams besides Merced River for which discharge records are available are Mariposa and Bear creeks, the estimated total annual run-off being 33,000 and 47,000 acre-feet, respectively.[2] Like other creeks which drain small areas of the lower Sierra foothills, their flow is torrential and subject to great variations both annually and monthly. Maximum flow occurs from February to April, the streams generally ceasing to flow by June 1st. The flooding of wild grass pasturage near the San Joaquin is the only present use made of these creeks.

The only canal diversion from the San Joaquin River in this area is that of the Stevinson Colony, which includes about 12,000 acres, of which 11,500 acres of cropped lands were irrigated in 1912. In addition this canal distributed flood water for flood irrigation of about

[1] 1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Hammond Hall, 1886; 1901-1910, U. S. Geol. Survey Water Supply Paper No. 299.

[2] 1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Hammond Hall, 1886.

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36,500 acres of grazing land. Newman on the west side is the nearest railroad station. The soil is generally sandy loam and is adapted to a variety of products.

Extensive ground water supplies occur in the lower parts of this area, artesian flow being obtained west of the Southern Pacific main line, the lift generally varying from 15 to 30 feet on the remainder. As far as indicated by present scattered developments, the quantity of water gives promise of being sufficient to ultimately supply a considerable area.

Some storage sites have been surveyed on the upper portions of Merced River and others probably exist. With the use of such storage as can be secured, and by adapting the use to the seasonal variations of stream flow, it should ultimately be possible to irrigate at least the full area under the present systems and possibly more from gravity supplies. An area lying north of Merced River and above Turlock Irrigation District might be irrigated from the Merced.

MODESTO-TURLOCK AREA.

This division includes the valley and plains for which the Tuolumne River is the most natural source of supply. It extends from the Merced River on the south to the Stanislaus River on the north, excluding only a part of the plains area north of Dry Creek now largely included in Oakdale Irrigation District. The total area is 450,000 acres, of which 315,000 acres are classed as valley land and 135,000 acres as plains. Of the valley land 22,500 acres consist of low lands along the San Joaquin River and outside of the irrigation districts which are subject to more or less overflow, and about 14,000 acres along the Tuolumne and Stanislaus rivers. The area irrigated in 1912 was 135,760 acres, of which 38,250 acres were in Modesto District and 96,900 acres in Turlock District.

Tuolumne River, which is now used by Modesto and Turlock districts, has the largest flow of any tributary of the San Joaquin. Discharge records covering twenty-one years are available, the mean annual flow having been 2,870 cubic feet per second, equivalent to 2,080,000 acre-feet per year.[1] May and June are the months of greatest discharge, the mean flow then being about 7,600 cubic feet per second. This decreases until in September the mean flow is but 220 cubic feet per second. The run-off of the maximum year of record has been somewhat less than twice that of the mean year and that of the minimum year about one half of the mean. Underground water has been but little developed in this section, as the present gravity systems are already constructed for much larger areas than are irrigated. Some artesian flow is found in the lower portions, but it is not used for irrigation. Pumping supplies could be developed over practically all parts of the valley lands, although as the foothills are approached the lifts become greater and the total quantity which may ultimately be developed more uncertain.

[1] 1878–84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, 1886; 1895–1910, U. S. Geol. Survey Water Supply Paper No. 299.

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Modesto and Turlock Irrigation districts were organized in 1887, the former covering 81,143 acres north of the Tuolumne and the Turlock district covering 176,210 acres on the south side. Although separate in organization, they have a common diversion dam near La Grange. Their progress met with similar difficulties of a legal and financial nature and it was not until 1901 that the Turlock system began delivering water, the Modesto District following the year 1904. Alfalfa is the crop of largest acreage, over two thirds of the total irrigated area being in this crop. Deciduous orchards, grapes, and garden products are also grown. The soils are generally of a sandy character,[1] those south of the river being more sandy than those on the north.

To increase the water supply in the late irrigation season, a foothill reservoir having a capacity of 30,000 acre-feet has been built by Modesto District, and the construction of two reservoirs holding 50.000 and 60,000 acre-feet, respectively, is contemplated by Turlock District. Other available sites are known in the upper drainage basin, the general opportunities for storage on the Tuolumne being better than on the other Sierra streams. Drainage has been found to be necessary in some portions of the districts, the ground water having risen to damaging heights since irrigation was started. Some drainage work has been done. Above the districts there are about 44,000 acres north of the Tuolumne and about 135,000 acres south of it that are properly classed as plains. Much of these lands can be irrigated from the Tuolumne if the water of the river is not taken to San Francisco for municipal use. The rights sought to be acquired by San Francisco cover water on the upper drainage area, including storage on Cherry and Eleanor creeks and at Hetch Hetchy. With the dams planned the proposed storage will have a total estimated capacity of approximately 500,000 acre-feet and furnish a supply of 400,000,000 gallons per day, equivalent to 450,000 acre-feet per day.[2] Other reservoir sites of various capacities have been surveyed. The total annual run-off in 1897–98, the minimum year of record, was 977,000 acre-feet. This is less than the estimated requirements of the two districts and of the city of San Francisco, but as the plans of San Francisco include sufficient storage to carry over some supply for low years, both the districts and the city should be able to secure the water needed, particularly as but one year of the twenty-four during which records have been kept gave less than the total estimated as being needed. With the development of additional storage, both in the mountains and in the foothills, much of the fine plains area above the districts should ultimately be susceptible of irrigation, even if a municipal supply is taken from the Tuolumne to San Francisco. In only five years of the twenty-one years of record has the run-off of the river fallen below 1,600,000 acre-feet, and in ten years it was over 2,100,000 acre-feet, the maximum recorded discharge being 3,750,000 acre-feet. By drawing upon the underground water to

[1]U. S. Dept. Agr., Bureau of Soils, Soil Survey of the Modesto-Turlock Area.

[2]Various reports submitted by City of San Francisco in the hearings on application for right of way in the Yosemite National Park for Hetch Hetchy reservoir site.

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supplement the gravity supply, the irrigation of a very large portion of the Modesto-Turlock area will be feasible if the Bay cities do not withdraw the large supply they are seeking.

SOUTH SAN JOAQUIN-OAKDALE AREA.

This area covers the lands most feasibly irrigated from the Stanislaus River. This area extends from the Modesto-Turlock area north to the Mount Diablo base line and includes the South San Joaquin and Oakdale Irrigation districts which are now constructing new irrigation systems which will reclaim the greater part of their areas. The area included covers 129,000 acres of valley and 110,000 acres of plains, a considerable portion of the latter being an even second bench that is very similar in character to the valley land.

But little use for irrigation has thus far been made of the Stanislaus, 3,550 acres being irrigated by gravity supply from Stanislaus River and about 450 acres by pumping plants in 1912. Discharge records for the river covering 18 years[1] show a mean flow at Knights Ferry of 1,930 cubic feet per second, equal to 1,400,000 acre-feet per year. April to June are the months of greatest flow, May, the maximum month, averaging 5,000 cubic feet per second. September, with a mean flow of 180 cubic feet per second, is the minimum month. The total run-off in the maximum years of record has been twice that of the mean, the minimum year 0.3 that of the mean.

The owners of the land in the South San Joaquin and Oakdale districts organized in 1909 and after some difficulties in marketing their bonds have construction well under way. Both districts plan to have an entirely new irrigation system commencing with the season 1913. South San Joaquin District covers the land lying north of the Stanislaus and in the lower valley, while Oakdale District lies on both sides of the river above South San Joaquin and Modesto districts. The old Tulloch system, which irrigated land within the present boundaries of these districts, was purchased with its water rights by the districts in 1910. A storage reservoir to contain 75,000 acre-feet is included in the plans of South San Joaquin District. The upper Stanislaus is used to develop a considerable amount of power, some storage for which is being provided. The irrigation of areas lying north of that at present included in the district is probably physically feasible if a water supply can be provided. The joint canal of the two districts is to have a capacity of 1,700 cubic feet per second, which will require more than the full flow of the stream after June in normal years. The extent to which other areas can be supplied during the later irrigation seasons depends on the storage that can be provided. No large reservoir sites are known and the total amount which it will be practicable to store will probably be less than on the other streams, although it should be possible to supply more than the present 140,000 acres included in the two districts. Ground waters of excellent quantity, with lifts varying from 15 to 30

[1] 1878–84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall. 1886; 1895–1900 and 1903–1910, U. S. Geol. Survey Water Supply Paper No. 299.

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feet, underlie the valley lands of the area and can be used to supplement irrigation from gravity systems. Along the lower portions near San Joaquin River ground water stands sufficiently near the surface to make irrigation not necessary, and the plans of South San Joaquin District include drainage for these areas.

STOCKTON AREA.

This area includes the valley and plains land in San Joaquin County exclusive of that in the South San Joaquin-Oakdale area and the delta lands and contains 256,000 acres of valley and 73,000 acres of plains, of which 13,320 acres of the valley lands are reported irrigated. Calaveras and Mokelumne rivers are the principal available sources of surface water supply, although now but little used for irrigation. Much of the lower half of the valley lands is quite intensively cultivated in orchards and vineyards. The benefits to be derived from irrigation have been the subject of much debate and as excellent returns have been secured without irrigation, the construction of large systems has been retarded. Irrigation is largely in small units of 5 and 10 acres which were first served by windmill and later by small engines. The soils are generally clay loams and clay adobe, hardpan underlying some portions at sufficiently small depths to influence crop growth.[1]

Calaveras River is a stream of irregular flow. Measurements made at Bellota from 1878–84[2] gave an estimated mean annual discharge of 520 cubic feet per second, equivalent to 377,000 acre-feet per year. Some records for 1907 to 1910, at Jenny Lind, are also available.[3] While the total annual run-off is perhaps not more variable than that of the other streams of the valley, the monthly and seasonal flow is much more irregular, separate months varying many hundred per cent in different years. April is usually the month of greatest flow, the discharge decreasing until the stream becomes entirely dry in July or August. The sudden floods on the Calaveras have been the cause of much damage to the city of Stockton, which is situated between two of the lower branches or sloughs. Protective measures are now being taken and storage construction in the foothills for flood protection is also contemplated. Any extensive use of the Calaveras River for irrigation will require storage. There is a site with an estimated capacity of 80,000 acre-feet which it is planned could be operated for flood control and also supply, when combined with the late natural flow, 50,000 acre-feet for irrigation. Such a system if feasible should be able to irrigate about 20,000 acres. Mokelumne River is a stream of comparatively large flow, yet the low discharge in the later irrigation season has as yet limited its use to the irrigation of about 2,200 acres. With storage a much greater use of this

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Stockton Area.
[2] California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, 1886.
[3] U. S. Geol. Survey Water Supply Paper No. 299.

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stream can be made. Discharge records covering 12 years are available.[1] These give an estimated mean annual discharge of 1,380 cubic feet per second, equivalent to 1,000,000 acre-feet per year. April to June are the months of highest flow, the mean discharge for May, the maximum month, being 3,640 cubic feet per second. September is the minimum month, the mean discharge having been 110 cubic feet per second. The maximum year of record has been one and two thirds the mean and the minimum slightly less than one half the mean.

But one system, that of the Stockton and Mokelumne Canal Company, diverts water from Mokelumne River. This canal covers about 32,000 acres lying east of Stockton and Lodi, of which but 2,200 acres are receiving water at present. All the irrigated land lies less than 40 feet above tidewater, the underground water being within range of root penetration on the lowlands. The history of this canal system consists of a series of financial difficulties and changes in control, although the present owners have improved and developed it. Many pumping plants are also used in this section.

There are large areas of valley land lying east of the Stockton and Mokelumne Canal which are susceptible of irrigation by gravity from Mokelumne River. Many pumping plants are operating in this area and the number is being rapidly extended. Any intended use of the Mokelumne will require storage. Reservoir sites are at present known which are estimated to have a capacity of 180,000 acre-feet.[2] The benefits of irrigation are becoming better appreciated and further use of the water of this stream is probable. At present pumping from underground supplies is the largest source of water supply, the holdings being generally small intensively cultivated orchards or vineyards. While the northern end of the general artesian belt underlies this area it is but little used for irrigation, the quality being poorer and the quantity obtained less than in the areas further south. Ground water in good quantities is obtainable generally at lifts of from 15 to 30 feet in the valley lands. The area reported irrigated from pumps is 11,120 acres, the number of plants being about 1,500. Many of these plants are owned by foreigners, largely Italians, and while the new installations are being made in small units, in the aggregate the total increase is materially influencing agriculture in this section. The increase from 8,642 acres in 1909 to 11,120 in 1912 for areas irrigated by pumping is at the rate of 10 per cent per year. With underground water available in such large quantities and small lifts a continuation in the present rate of increase in use is to be expected. Eventually it is also probable that the flow of Calaveras and Mokelumne rivers will be utilized, more probably

[1] 1878-84, California Engineering Dept., Physical Data and Statistics, Wm. Ham. Hall, 1886; 1905-10, U. S. Geol. Survey Water Supply Paper No. 299.

[2] Reports submitted by San Francisco in hearings for Hetch Hetchy permit, August, 1912.

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on the higher valley and plains lands where ground water is not accessible.

SAN JOAQUIN DELTA AREAS.

The lower course of San Joaquin River is through an area of isla and overflow land whose physical and agricultural characteristics materially different from the general valley areas. This area inclu the swamp land segregation from near Tracy and Lathrop to the no line of San Joaquin County and contains approximately 315,(acres, of which 177,600 acres are considered irrigated by standard adopted. San Joaquin River divides into 3 channels, (River, the most westerly, Middle River, and the present San Joaqu which passes near Stockton. The area between these channels, wh unite near the mouth of the Mokelumne River, comprises abo 120,000 acres, which is divided by the various sloughs and draina canals into islands varying from 1,000 to 12,000 acres in size of wh 89,000 acres are irrigated. Most of these islands have been reclaim by the construction of levees to prevent overflow, the work bei largely done by organized reclamation districts, and the reclamati of others is now in progress. The remaining unirrigated ar consists largely of Bouldin, Madeville, and Bacon islands and vario sloughs, lakes, and water channels. Efficient water transportation furnished by these numerous channels.

The soils are composed of a mixture of silt and more or less decay vegetable matter and are locally known as peat soils.[1] These a usually saturated at depths of 2 or 3 feet or less. Pumping plan are maintained both to pump water from the sloughs onto the lar for irrigation and also for the reverse process of drainage. Th usual method of irrigation is by the slow passage of water throug ditches about 1 foot wide and 2 feet deep spaced 60 to 80 feet apar these saturating the intermediate ground. Considerable alkali is pre ent but its harmful rise is prevented by the low capillarity of th loose vegetable soil. Potatoes, beans, asparagus, onions, and celer are the most important crops, barley being also grown largely fo rotation with potatoes. But little alfalfa is raised as the depth t water is not generally sufficient for deep root growth. The peculia characteristics of these soils are quite fully utilized in the productio of the crops for which they are best adapted. They are more affecte by an over supply of water than by a scarcity and no developmen on the tributary rivers will ever be so complete but that waste an return flow will be sufficient for these lower areas.

Very similar to the islands between the channels of San Joaqui River are those between the main Mokelumne and the slough know as South Fork of the Mokelumne. About 20,000 acres are include in the three main islands, of which 13,000 acres are irrigated.

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Stockton Area.

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There is also a large area lying above the main sloughs that is subject to overflow and merges from conditions similar to those in the islands to those of the non-overflowed valley land. There are about 75,000 acres of this land lying west of Old River in Contra Costa County and 100,000 acres lying east of the main channel of the San Joaquin and the South Fork of Mokelumne River. These areas are largely protected by levees and are cultivated by methods similar to those used on the islands, and no shortage of water is felt. The area at present irrigated is 40,600 acres in the eastern portions and 35,000 acres in the western. The reclamation of further areas is to be expected here.

SUMMARY.

The summary of the various separate areas gives a total of 6,530,000 acres of valley and 1,046,000 acres of plains of which 1,705,745 and 23,230 acres are reported as now irrigated. The total discharge of the measured streams, which includes all of importance, has been 11,516,000 acre-feet per year in years of mean run-off and 4,955,000 acre-feet in the year showing the minimum discharge of record. The quantity which may eventually be secured from ground water may total 5,000 cubic feet per second.

Any statement of the present area irrigated or estimate of the ultimate area which can be irrigated in San Joaquin Valley must of necessity depend somewhat upon the standards of classification which are adopted. The present practice varies from intensive cultivation and irrigation from concrete pipe and stands in the orange groves, as about Porterville, to the crude, unrestrained overflowing of low land pastures. Any understanding of the possibilities of future development in irrigation in this valley requires a broad appreciation of the variable factors which may make each of these extremes the most economic use under certain conditions, although the circumstances that make the lower grade methods the more economic ones at present can be largely remedied in the future.

The area given as at present irrigated is based on careful reconnaissances covering the whole valley, checked by the reports of canal companies and the census of irrigation, and should be substantially correct. Land which generally receives water artificially for the benefit of any crops that may be grown, including pasturage, is classed as irrigated even though in occasional years of low stream flow no water may be applied. Any discussion of the areas which may ultimately be irrigated involves many variables and depends quite largely on the personal point of view. Developments which now excite no unusual comment would have been impracticable a generation ago and prophesies involving conditions a generation in the future may be similarly in error. In looking ahead, however, the present has one advantage over the past in that tendencies have now been established whose continuance is reasonably certain and from which the possibilities can at least be

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approximated. Among these are the increasing value of land and the necessity for its utilization in such a way as to produce returns in proportion to its value; the growing appreciation of the advantages and needs of irrigation if these higher returns are to be obtained; and the approach of the amount of water used to the easily available supplies, this approach stimulating both the more careful use of present direct flow and underground waters, and the development of those as yet unused. All these tendencies, which even causual study shows must continue at increasing rates, make it evident that economic conditions will eventually force a full utilization of available irrigation possibilities.

It is on this basis that the estimates of the area which may ultimately be irrigated have been made. Not only will the acreage be increased but the character of crops grown will be improved, although it is possible that wild-grass flooding will always be the most economical use of part of the most variable part of the stream flow.

While the surface flow of the streams and the underground waters are rather closely related, the developments which will be made from each of these sources can best be discussed separately, because of the differences in the amount of available data relative to their quantity and in the factors which will influence their use.

The low-water flow of all San Joaquin Valley streams can be considered either as fully used at present or as being appropriated by projects under active construction, except the waste and return water in the lower San Joaquin River itself. This applies to the discharge in the later months of the irrigation season. As the flood stages of all streams draining the higher Sierra occur generally in May and June, much of the discharge during this period is undiverted. There are two methods of more fully making crop uses and the seasonal variation of stream-flow more fully coincide; viz: by storage of flood discharge for use as desired and by adapting irrigation to the available water supply, which is really ground storage. Only the second of these methods has been used to any extent in San Joaquin Valley. While but few data regarding feasible reservoir sites are available for this division as a whole, the general conditions and such detailed surveys as are known make it reasonable to conclude that much reservoir capacity can be secured at feasible costs. That this has not been done has been due largely to legal conditions which make uncertain the rights of those storing water as against the rights of riparian owners, and also to the general climatic conditions which permit irrigation during most of the year. It has been cheaper to use water when available, expecting the soils to retain a portion of the amount applied for the use of the crops in the months of low flow, than to undertake the uncertainties of reservoir storage. With the value of water increasing, the stage is being reached where it will be more economical to store excess waters for application when most needed than to use the larger quantities

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necessary in ground-storage practice. While the use of water whenever available is much to be preferred to no use at all, the best returns from the valuable fruit and forage crops can not be obtained unless late-season irrigation can be secured. A general examination of the annual and seasonal variations of stream-flow in this division shows that even with the use of as much storage as can be considered feasible, not over two thirds of the run-off can be made available for use on the most desirable seasonal distribution. That so many of the streams have already passed this figure is evidence of the advantages of the present practice of adapting the amount used to the available supply. It is for this reason that the construction of storage will add to the value of the irrigated crops more than to the total acreage.

The table below shows the comparative use which is now being made of the different streams. The use of Kings River is the most complete, due to several factors, among which are the high ground water plane, the irrigation of a large area of vineyards which require little water, and the use of practically all flood and waste water on forage crops in the lower areas.

Table showing discharge of and areas irrigated by principal streams in San Joaquin Valley.

River.	Mean annual run-off. Acre-feet.	Run-off in minimum year of record. Acre-feet.	Area irrigated by stream at present. Acres.	Mean annual run-off in acre-feet divided by area irrigated.	Minimum annual run-off in acre-feet divided by area irrigated.
South of San Joaquin River:					
Kern	770,000	288,000	176,220	4.4	1.6
Tule	148,000	70,000	47,775	3.1	1.5
Kaweah	533,000	252,000	109,700	4.9	2.3
Kings	1,920,000	884,000	628,780	3.05	1.4
Totals	3,371,000	1,494,000	962,475	3.5	1.6
North from San Joaquin River:					
San Joaquin	2,060,000	924,000	[1]344,100	6.0	2.7
Merced	1,228,000	518,000	[2]67,800	18.1	7.6
Tuolumne	2,080,000	977,000	135,320	15.4	7.2
Stanislaus	1,400,000	389,000	4,800	----	----
Calaveras	377,000	174,000	----	----	----
Mokelumne	1,000,000	479,000	2,200	----	----
Totals	8,145,000	3,461,000	554,220	----	----
Grand totals	11,516,000	4,955,000	1,516,695	----	----

[1]Includes 177,600 acres of delta lands partially supplied by run-off of tributary streams, but does not include 122,000 acres of pasture artificially flooded from San Joaquin River in 1912 or 68,000 acres of pasture naturally flooded in 1912 from the same stream. In normal years the pasture artificially flooded from San Joaquin River is about 14,000 acres more and the naturally flooded pasture 5,000 acres more.

[2]Includes all lands holding water rights under Crocker-Huffman canal; only 19,500 acres actually irrigated under that canal in 1912.

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While the same average of 1 acre irrigated for each 3 acre-feet
mean annual run-off may be attained on the Kern, Tule, and Kawe
rivers as on the Kings, it is hardly to be expected on those farther
the north where, so far as is known, the same opportunities for utilizi
flood-flow do not exist. This average may be attained on the main Sa
Joaquin, exclusive of its tributaries, if the delta lands are include
by the use of pumping to the northern west-side valley areas and furth
use in the upper portion through storage. At present the streams fro
Kings River south average 1 acre irrigated for each 3.5 acre-feet of mea
annual run-off. While the utilization appears to have approached th
economic limit on these streams, storage and prevention of seepag
losses in canals and stream beds should permit some increase in are
By including the minor streams not in the table, the total dischar
of the streams from Kings River south in mean years is 3,820,00
acre-feet which at a duty of 1 acre for each 3 acre-feet would suppl
1,270,000 acres by gravity. On Kings River, the area irrigated ma
be increased through storage and improvements in canals, so that th
streams in this portion of the valley may be estimated as capable
supplying a total of 1,350,000 acres as a probable maximum. Thi
increase should be accompanied by a large increase in crop return
due to more intensive cultivation, as it is only by such intensive cult
vation that much of this increase will be economically practicable. A
this is only about one third of the available agricultural land, no deta
study as to whether land and water can be brought together is needed
The streams are distributed so that ample land is available for eac
source and it is only on the west-side lands that no part of large contin
uous areas will be irrigated.

While the division between the streams from Kings River south an
the San Joaquin and its direct tributaries is a natural one, the ind
vidual differences between the northern streams and their agricultura
areas make a more detailed consideration of the possibilities advan
tageous. As shown by the preceding table, the use of these stream
is much less complete than the use of the southern ones. This ha
been due most largely to the greater possibility of obtaining fair return
by the dry-farming of grain. With the greater returns of irrigatio
now fully appreciated, full utilization of the opportunities is to b
expected.

The San Joaquin is the river of next to largest discharge and
largest present use in the northern part of the valley. As shown b
the average of 1 acre irrigated for each 6 acre-feet of mean annua
run-off, this stream should be capable of supplying a much large
area. Such an increase is to be expected eventually, for while muc
of the tributary land is now perhaps best adapted to grain and forag
crops irrigated by wild flooding, yet there is sufficient land capabl
of intensive cultivation on the lower west side and in Madera Count
to fully utilize its discharge. There is also a greater opportunity t
make use of any flood or waste waters on this river due to its greate

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length. Besides the run-off of its own mountain drainage, it receives the excess of the east-side streams which are available for use in the lower delta lands. Considering these delta lands as part of the area irrigated from the San Joaquin, a general duty of 1 acre for each 3 acre-feet of mean run-off should be attained, or a total of nearly 700,000 acres. The present conditions of ownership of riparian lands and control of water rights will probably postpone any such complete utilization of this stream, although eventually the value of its use should force the full economic development.

Tuolumne River is slightly larger than the San Joaquin. It is the only stream in the valley whose discharge is capable, when fully utilized, of irrigating its adjacent valley and plains land. The mean annual run-off can supply the 473,000 acres of agricultural land reported available at the rate of 4.4 acre-feet per acre. As the opportunities for storage are considered better than on any other Sierra stream, the Tuolumne can be considered as capable of irrigating this full area and also supplying some municipal water supply for the Bay cities, although the ultimate diversion of 400,000,000 gallons per day for use by the cities of San Francisco Bay, as now estimated to be required, will leave a mean annual run-off of 3.5 acre-feet for each of the 473,000 acres of agricultural land or only 1.1 acre-feet in minimum years.

Of the other streams, the Stanislaus and Merced rivers are the most important. Although present use is not large from these, constructed systems can serve much additional area. It is hardly to be expected that as large an area proportionately will be irrigated as on the southern rivers, as rainfall conditions are more favorable. Stanislaus River should irrigate the 140,000 acres of the two present districts and eventually additional area to the north. The irrigation of 300,000 acres from this stream would be at the rate of 1 acre for each 4.5 acre-feet of mean annual run-off and should be feasible when the demand for its use arises. A somewhat larger use of Merced River is probable as irrigation is more necessary in this portion of the valley, and 300,000 acres may ultimately be irrigated.

The only other stream of large run-off is the Mokelumne, which as yet has been little used. While agriculture without irrigation or irrigation by pumping is already well established in its tributary areas, so that its use will be slower than on the other streams, it can be considered as capable of ultimately irrigating probably 100,000 acres. The other various streams have a total mean annual run-off of 668,000 acre-feet. Calaveras River furnishes over one half of this and with storage may supply 40,000 acres. The remaining run-off is derived from the Fresno, Chowchilla, Mariposa, and Bear creeks in Madera and Merced counties and with storage may supply 60,000 acres.

Summarizing the various streams from the San Joaquin River north, the total area for which it may be estimated that a surface water supply may be obtained is 1,900,000 acres.

The above discussion covers the sources of surface water supply

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of San Joaquin Valley. The records of stream-flow furnish fairly complete data as to the available water from these sources, leaving only the extent of its use to be estimated. With the underground water both the quantity and its probable use must be estimated. A general description of the ground waters based on field work in 1905 has been published.[1] It is estimated in this report that the ultimate amount of ground water developed may be ten times that then developed in southern California, or 5,000 cubic feet per second.[2] At that time about 300 cubic feet per second was being developed in the San Joaquin Valley. This has been more than doubled since. If 5,000 cubic feet per second is obtained for 6 months of the year it will equal a total of 1,810,000 acre-feet or approximately 15 per cent of the total mean annual discharge of the streams at the edge of the valley. Considering the generally open structure of the subsoils the seepage of this amount or more can be considered as reasonable. Increase in gravity irrigation should increase the quantity reaching ground supplies. Groundwater in sufficient quantity for irrigation can be obtained in all parts of the valley proper, except in the west-side areas. In the lower valley floor artesian flow can be secured, although this is not extensively used for irrigation. While the quantities available decrease and the lifts required increase from the valley trough to the east-side foothills, the value of the products which can be grown increases, so that the highest development may be found in the regions of smallest groundwater supply. As pumping for irrigation requires both an initial cost and an operation expense that are plainly evident to irrigators, the pumped water is generally used more economically than that from gravity canals. As a large portion of the water at present pumped is used to supplement the water received from canals, it is not reasonable to expect the area irrigated from ground water will be entirely additional to that irrigated from canals. While any estimate of the total possibilities of the ground supplies must be liable to much uncertainty, the area eventually irrigated wholly by this means will certainly be several times that at present supplied and may reach a total of 600,000 acres. While use of ground water will be rather general throughout the lower valley floor and east-side plains, the largest use will be where gravity supplies are the least accessible, as in San Joaquin County, or where supplemental pump supplies are the most profitable, as in the Fresno district.

Any such extensive development as has been outlined both from stream and groundwaters can only occur by gradual increase through a long period of time, even with favorable legal and economic conditions. A large population is a first requisite for such intensive cultivation as will be required and settlers can not be obtained for such large areas in a short period. Removing all possible legal hindrances to legitimate development and uncertainties as to water-right conditions will hasten the time when the possibilities of this great valley may be realized.

[1] U. S. Geol. Survey, Water Supply Paper No. 222.

[2] It is understood that a new report is being issued by the Geological Survey on the underground waters of San Joaquin Valley and the preliminary estimates given in Water Supply Paper No. 222 are likely to be changed to conform to results of their later studies.

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Summarized briefly, the situation may be stated as follows: In San Joaquin Valley from Kings River south are 4,662,000 acres of valley and plains land of which 1,136,910 acres are now irrigated and 1,650,000 acres for which it is estimated a water supply can be obtained. Of the agricultural area which must remain without a water supply, roughly 1,400,000 acres can be considered as being west-side and south-side lands and the remaining 1,750,000 acres as divided among the east-side areas. From San Joaquin River north are 2,914,000 acres of valley and plains lands with 592,065 acres irrigated and 2,200,000 acres for which it is estimated a water supply can be obtained. The areas which will remain unirrigated are scattered. Taken as a whole the valley and plains lands total 7,576,000 acres, with 1,728,975 acres irrigated and 3,850,000 acres irrigable. Present development is approximately 45 per cent of the estimated ultimate, and the estimated ultimate approximately 50 per cent of the whole area.

SIERRA FOOTHILLS ABOVE SAN JOAQUIN VALLEY.

The Sierra foothills in central California comprise a belt of land on the western slope of the Sierra Nevada bordering the San Joaquin valley and plains. The foothill territory covered in this report extends southerly from Mokelumne River to the Kern. Between the Kern and Tehachapi Mountains, at the southern end of San Joaquin Valley, the foothills rise abruptly from the valley floor and are followed by ranges gradually increasing in height until the summit of the Sierra is reached. The cultivable areas are found largely along the foot of the slopes or in small valleys or coves back of the first range of hills, as in the Tulare County citrus belt. This area south of Kern River is comparatively small and has therefore been included in the San Joaquin Valley plains. In investigating the arable areas in the foothills an altitude of 2,500 to 3,000 feet was taken as the upper limit, since above this irrigation is little practiced. The agricultural areas included are largely broken and scattered and while in some cases owing to topographic features and shallow soil no irrigation may be practiced, it has not been practicable to eliminate minor areas. The upper portions of the foothills are generally covered with a coarse growth of underbrush, small oak, and a second growth of yellow pine. In the lower portions adjacent to the plains grain is principally grown without irrigation.

The Sierra foothills have been so closely identified with mining that until recently little attention was paid to agricultural pursuits. Early miners who set out small orchards demonstrated the success of fruit-growing, but generally only enough fruit was raised to supply the local demand. Stock raising will always be an important industry. The lack of transportation has been a serious handicap to agricultural development and there are still fertile sections whose products must be hauled long distances to railroads. In many places ditches are already

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provided, having been constructed at an enormous cost for mining operations. Irrigation and the generation of power give new ways for the continued use of these ditches.

The streams which have their source in the Sierra constitute the available supply for the foothills as well as for San Joaquin Valley. The available discharge records and possibilities of the various rivers are discussed with the more important areas in San Joaquin Valley. Generally there are larger areas of valley lands available for each source than can be supplied. While the water resources may generally be considered as equally available for foothills or valley lands, extensive areas under single projects are not to be expected in the foothills, because of the generally broken character of the topography. Underground waters are not usually available, although springs are used to a certain extent.

The following tabular summary gives the location of the arable land in the foothills in central California by counties according to their location between the principal river systems, with the acreage of agricultural and irrigated land:

Summary of agricultural land in Sierra foothills above San Joaquin Valley.

Area.	County or counties.	Foothill agricultural land. Acres.	Areas irrigated. Acres.
Between Mokelumne and Calaveras rivers	San Joaquin	37,500	0
Between Mokelumne and Calaveras rivers	Calaveras	54,500	560
Between Calaveras and Stanislaus rivers:			
Lower foothills	San Joaquin, Stanislaus and Calaveras	115,000	40
Salt Springs Valley	Calaveras	47,000	100
Vicinity of Andreas and Angels Camp	Calaveras	15,000	570
Between Stanislaus and Tuolumne rivers:			
Lower foothills	Stanislaus and Tuolumne	46,000	40
Vicinity of Sonora	Tuolumne	81,000	2,300
Between Tuolumne and Merced rivers:			
Lower foothills	Stanislaus, Merced, Tuolumne, and Mariposa	53,000	0
Vicinity of Coulterville	Tuolumne and Mariposa	22,000	230
Between Merced and San Joaquin rivers:			
Upper Bear Creek drainage area	Merced and Mariposa	67,000	0
Upper Mariposa Creek drainage area	Mariposa	62,000	0
Upper Chowchilla Creek drainage area	Mariposa	50,000	40
Upper Fresno River drainage area	Mariposa	27,000	200
Madera County areas	Madera	18,000	40
Upper Kern River valleys	Kern	35.000	6,500
Totals		730,000	10,620

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AREA BETWEEN MOKELUMNE AND CALAVERAS RIVERS.

This area comprises a total of 92.000 acres of agricultural land, of which 560 acres are reported irrigated from Mokelumne River and tributaries. Irrigation is confined to vegetables and small orchards, water being obtained from old mining ditches. In the lower foothills grain is grown without irrigation and conditions are similar to those in the adjacent San Joaquin plains. The mean annual rainfall at Mokelumne Hill at an elevation of 1,500 feet is 32.5 inches. All kinds of deciduous fruits can be profitably grown with irrigation. It is probable, however, that stock raising will continue to be the principal industry in this area.

AREA BETWEEN CALAVERAS AND STANISLAUS RIVERS.

This area, comprising 177,000 acres, has been segregated into three principal divisions. The lower foothills, including 115,000 acres adjacent to the San Joaquin plains, are utilized largely for grazing and the growing of grain. Salt Springs Valley, lying between Gopher Ridge and the Bear Mountains, forms the second group of 47,000 acres. The remaining 15,000 acres are found in the upper foothills between San Andreas and Angels Camp. The agricultural areas here follow along the creek bottoms, the hills being too steep and rocky for farming. Mining still predominates in the upper foothills, agriculture having been developed only to the extent of supplying local markets. The irrigated area in 1912 amounted to 710 acres, consisting mostly of small orchards and vegetable gardens. The soil is generally of a red clay or gravelly loam and when of sufficient depth is well adapted to the growing of fruit. Numerous ditches are already built capable of supplying a large area when the demand for irrigation is created.

AREA BETWEEN STANISLAUS AND TUOLUMNE RIVERS.

Lying between Stanislaus and Tuolumne rivers it is estimated that there are 127,000 acres of agricultural land, of which 2,340 acres are irrigated mainly by diversions from the South Fork of Stanislaus River. Owing to the more important industries of mining and lumbering there has been no real impetus to agricultural development. Farming is limited to the growing of grain and hay. The early miners set out a number of small orchards for the purpose of supplying fruit for domestic use. Where the trees received sufficient care, fruit of good quality was successfully grown.

The success of the fruit industry must depend largely upon irrigation. The soils are the result of the weathering or decay of underlying rocks, and on the hilltops it may be only a few inches deep. The average annual precipitation at Sonora for twenty-three years is 35.79 inches, almost all of which falls during the winter months. Owing to the shallow soils, steep slopes, and consequent natural drainage, very little of the moisture is retained in the soil for the dry season.

The principal water supply for irrigation is supplied by the Sierra and San Francisco Power Company, which has succeeded to the rights and properties of the Tuolumne Water Company. Water is diverted

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from the South Fork of Stanislaus River and delivered to lands in the vicinity of Sonora, Columbia, Jamestown, Soulsbyville, and Tuolumne. The charge for water is 12½ cents per miner's inch per 24-hour run. It is locally estimated that 24,000 acres in this territory are so situated that irrigation could be easily accomplished, and by constructing present known storage it has been estimated that water can be furnished for about 19,000 acres. The remaining areas are best adapted to grain and grazing. Transportation is afforded by the Sierra Railway, which connects Tuolumne with Oakdale on the Southern Pacific.

AREA BETWEEN TUOLUMNE AND MERCED RIVERS.

This consists of 53,000 acres of low rolling hills and 22,000 acres of scattered areas in the vicinity of Coulterville. Two hundred and thirty acres are reported irrigated. Conditions are similar to those in the area north of the Tuolumne River. The lower foothills are devoted almost exclusively to the growing of grain and grazing, and it is probable that in the higher foothills the stock industry will continue to predominate. A few oranges and lemons have been grown successfully for many years at La Grange, indicating what may be accomplished in time in favored localities of the foothills.

AREA BETWEEN MERCED AND SAN JOAQUIN RIVERS.

Soils in this area are chiefly of red clay loam characteristic of the Sierra foothills. The topography in general consists of numerous irregular plateaus separated by the narrow valleys of Merced River and Bear, Mariposa, and Chowchilla creeks, which are the principal streams. Merced River has a large run-off, but does not flow through the larger areas of agricultural foothill land, so its full use is more profitable in the main San Joaquin Valley. The run-off of the smaller streams is torrential and uncertain. Irrigation is confined to a few small gardens and fruit farms which depend upon springs and wells for their water supply. About 280 acres were irrigated from these sources in 1912. The agricultural area included in this group comprises 206,000 acres.

The only railroad which traverses this section is the Yosemite Valley Railroad, which follows along Merced River and connects with the Southern Pacific and Santa Fé railroads at Merced. Owing to the lack of transportation facilities, diversified agriculture has been limited to the demands of the local markets and any extensive irrigation development will be retarded until railroads are provided. In some cases, such as Chowchilla Valley, where soil and climatic conditions are adapted to special crops such as apples, local development may be important. Irrigation development as a whole will likely be slow, since the greater part of the available water may be had only after expensive storage works are constructed. Large areas of fertile land in the valley below which must look for their water supply in the Mariposa watershed will naturally be the first to be benefited. South of the Mariposa areas are 18,000 acres of foothill land in Madera County included in this division. The rolling hills are broken in numerous places by outcroppings of rock and are chiefly valuable for growing grain and grazing. It is doubtful

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if irrigation will ever be practiced, although the possibility of growing citrus fruits in sheltered portions may lead to some local development.

UPPER KERN RIVER VALLEYS.

The valleys of upper Kern River, while not distinctly a part of the Sierra foothills, have been included in this division. The area comprises about 35,000 acres, the greater part of which lies along the South Fork of Kern River at a mean elevation of 2,500 to 3,000 feet. Six thousand five hundred acres are reported irrigated, consisting mostly of alfalfa, wild grasses, and a few orchards. Kernville, Isabella, and Onyx are the principal towns and are reached by stage connecting with the Southern Pacific Railroad at Caliente. Stock raising and mining will always predominate. No great increase in irrigation can be expected in this section owing to the valuable hydroelectric power rights which have become vested on upper Kern River and its tributaries.

SUMMARY.

An estimate of the area which may ultimately be irrigated in this division is more difficult to make than in others of central California. The valley areas available are generally larger than can be supplied from the streams on which development in the foothills must also depend. The lower foothills, which comprise over one half of the total area, while similar to the valley plains are generally more rough in character and will probably be the last to be benefited by irrigation. In the upper foothills the agricultural areas are more scattered, and being smaller in extent it is doubtful if costly storage works would be justified for their reclamation. With better transportation facilities and a more general interest in diversified agriculture, it is safe to predict that from 40,000 to 50,000 acres may eventually be irrigated in the Sierra foothills above San Joaquin Valley.

VALLEYS EAST OF THE SIERRA NEVADA.

This division includes the portion of central California lying east of the Sierra Nevada and in the Great Basin drainage. The altitude of the agricultural areas varies from 3,700 to 7,000 feet, the streams arising at elevations of from 8,000 to 14,000 feet. In the valleys the available records of rainfall show a mean annual precipitation varying from 3.06 inches at Keeler to 14.49 inches at Bodie. The general agricultural characteristics are quite similar to those of the plateaus and valleys in northern California, forage crops and some grain predominating. Of a total area of 8,700,000 acres in the three counties, 472,000 acres are classed as agricultural and so situated as to be irrigable if a sufficient water supply can be procured, of which 137,760 acres were reported irrigated in 1911.

While this section has long been settled and irrigation has long been practiced, its fullest development has been retarded by the lack of adequate transportation facilities. The recent construction of a rail-

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road to Owens Valley from the south has greatly improved this feature. The crops raised have been largely those consumable by the stock industry and as is usual in such cases the methods of irrigation are more crude than with the more intensive agriculture.

The separate agricultural areas are not numerous, as shown by the following table:

Summary of agricultural and irrigated areas in the valleys east of the Sierra.

Area.	County or counties.	Agricultural land. Acres.	Area irrigated. Acres.
Alpine County	Alpine	3,500	3,35
Antelope Valley	Mono	22,100	16,70
Bridgeport Valley	Mono	24,200	19,10
Area southwest of Mono Lake	Mono	19,000	2,72
Area north of Mono Lake	Mono	63,000	1,36
Owens River areas:			
Adobe Meadows	Mono	27,000	
Valley north of Bishop	Mono and Inyo	77,000	26
Long Valley	Mono	21,500	18,70
Round Valley	Inyo	8,700	5,63
Owens Valley, Bishop to Aberdeen	Inyo	100,000	47,40
Owens Valley, Aberdeen to Owens Lake	Inyo	98,000	21,90
Owens Valley, west and south of Owens Lake	Inyo	8,000	64
Totals		472,000	137,76

ALPINE COUNTY.

Irrigation in Alpine County is confined to the valleys of the west and east forks of Carson River, 2,950 acres being irrigated from the west fork and 400 acres from the east fork. The former area extends from Woodfords to the Nevada line; the latter lies in the vicinity of Markleeville. But 3,500 acres are reported as being susceptible of irrigation from reported ditches. Forage crops predominate and general conditions are similar to those in the other larger areas of this division.

ANTELOPE VALLEY.

Antelope Valley, in the northern part of this division, lies at an altitude of from 5,000 to 5,500 feet and extends into Nevada along West Walker River, by which it is watered. Forage crops are raised almost entirely, meadow hay predominating. The Rickey Land and Cattle Company own the main part of the valley land and also the irrigation canals. Records of the discharge of West Walker River at Coleville gave a total run-off of 156,000 acre-feet in 1905 and of 490,000 acre-feet in 1907, the drainage area being 306 square miles.[1] The statement of the total area of irrigable land in this valley in California is based on the investigations made by the United States Reclamation Service, which contemplated using Alkali Lake as a reservoir for the irrigation of lands in Smiths Valley, Nevada. The total area of agricultural land reported

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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in Antelope Valley is 22,100 acres, of which 16,700 are irrigated more or less completely, the area at present unirrigated lying above the canals and being of a generally rougher character. A water supply can be considered available for the total area, as with economy in present methods the amount now used would be sufficient. However, the irrigation of the remaining area is not considered probable for some time at least. Over-irrigation has caused the swamping of a large area in the vicinity of Topaz, and more care in the application of water as well as drainage in some portions is needed.

BRIDGEPORT VALLEY.

Bridgeport Valley consists of 24,200 acres of agricultural land lying in the broad bottoms formed by Robinson, Buckeye, and Swager creeks and East Walker River, of which 19,100 acres are classed as irrigated, including about 1,200 acres in Huntoon Valley on upper Swager Creek, which is separate from the main area. The mean elevation is approximately 6,500 feet, meadow hay and pasture being the only crops raised. These are irrigated by the wasteful wild flooding methods prevalent in other similar areas where land holdings are large. The land classed as agricultural but not at present irrigated is in the upper portion of the valley along East Walker River and at the lower end above the irrigated land. A swamp area of about 4,000 acres caused by over-irrigation occurs in the valley and is excluded from the agricultural area. The water supply is more than required for all the agricultural land, its abundance having been the chief cause of its over-use. The irrigation of the remaining area, which is rougher and more rocky than the main valley, may be accomplished in time, although drainage of the swamps whose area is being increased, if economically practicable under present crop returns, is the most urgent need.

MONO LAKE AREAS.

Lying southwest of Mono Lake, in the vicinity of Rush and Leevining creeks, is an area of 19,000 acres, of which 2,720 acres are reported irrigated. Mono Lake, at an elevation of 6,400 feet, has an area of approximately 85 square miles, the evaporation from which is a measure of the run-off received. No evaporation measurements have been made on this lake, but at Owens Lake to the south and 3,000 feet lower in altitude it is approximately 70 inches, and at Lake Tahoe in the mountains to the north it is about 30 inches, so that the mean evaporation here may be estimated as 50 inches per year, equivalent to 225,000 acre-feet from an area of 85 square miles. Rush and Leevining creeks drain 150 square miles of the eastern slopes of Mount Lyell and the higher Sierra and are estimated to furnish one half of the run-off received by the lake. Many small lakes are formed along these creeks and by the use of some storage the water supply can be considered sufficient for the area reported. Its use is not probable, however, because of the climatic conditions, which largely limit agriculture to the growing of native hay, so that it is to be expected that this area will continue to be devoted at as present mainly to stock interests.

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There is also an area lying north of Mono Lake containing 68,000 acres, 1,360 of which are irrigated. Mill and Wilson creeks are the principal streams and are used to supply the area at present irrigated. Mill Creek is one of the principal tributaries of Mono Lake, and with storage could be made to supply considerable additional area, general conditions being similar to those in the lands along Rush and Leevining creeks. The agricultural land lying in the eastern part of this area is backed by an arid drainage area of approximately 200 square miles, from which there is practically no surface run-off. The irrigation of this land can not be considered feasible, as because of climatic conditions the crop returns would not be sufficient to make any expensive systems financially successful.

OWENS RIVER AREAS.

The remaining areas of this division lie in the general Owens River drainage basin. Owens River receives the drainage from a length of about 100 miles along the east slope of the Sierra, its valley land comprising the largest agricultural area in this division. White, Inyo, and Coso mountains on the east yield but little run-off. Including Long and Round valleys, there is a total of 340,200 acres of agricultural land reported, of which 94,530 are irrigated. The mean elevation is 3,900 feet. The temperature at Independence ranges from 105 degrees to 3 degrees, the mean being 58 degrees, with a mean annual rainfall in the valley of approximately 5 inches. The 160-acre homestead is the typical holding and forage and grain are the principal crops, both alfalfa and native grasses being raised.

In 1903 the United States Reclamation Service carried on various investigations for the purpose of determining the feasibility of constructing further irrigation systems. Storage in Long Valley was contemplated. A reconnaissance of the lands in the main valley was made and it was estimated that there were 75,000 acres of first class and 50,000 of second class land requiring only water to be of value, 80,000 acres requiring drainage and washing, with 75,000 acres too rough for irrigation or waste land from other causes. The soils of the west side are derived from the Sierra and are granitic, those from the mountains on the east having a general limestone character. Over-irrigation has caused much of the bottom land to be affected with alkali. Drainage has been successfully tried on a few individual farms and more comprehensive systems should be feasible. The proposed project of the Reclamation Service was abandoned in favor of the Los Angeles aqueduct. The city of Los Angeles is building an aqueduct at an estimated cost of $24,500,000 to convey a mean flow of 430 cubic feet per second from the Owens River drainage a distance of 220 miles to provide for its future municipal needs. Large areas of land and five canals were purchased in Owens Valley in order to obtain their water rights. Storage in Long Valley is contemplated, other reservoirs along the aqueduct line also being included in the system. Diversion is made from Owens River, near Aberdeen, about 12 miles north of Indepen-

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dence, the capacity of the canal being 700 cubic feet per second at this point. This capacity is increased to 900 cubic feet per second as the various west-side creeks are collected and added to the canal. Haiwee reservoir south of Owens Lake will be used to equalize the seasonal flow, the capacity of the canal being 430 cubic feet per second below this reservoir.

Extensive hydrographic studies have been carried on in connection with this project, particularly in regard to the recovery of underground water. Much water seeps from stream beds and from irrigation ditches and irrigated fields which experiments have shown is now largely lost by evaporation from the lower valley lands, the depth to ground water fluctuating between 3 and 8 feet. By lowering this ground water below the effects of surface evaporation, it is estimated that a mean flow of 75 cubic feet per second can be developed. It is planned to use such waters as part of the Los Angeles supply, as the surface stream flow in some years falls below requirements. Artesian flow is secured in some deep wells bored near Independence. Underground water occurs in good quantities, with low lifts beneath the lower lands in much of the valley, and these sources may ultimately be used to some extent.

While the agricultural land is continuous throughout the main Owens Valley, it can be separated into sections for the purposes of discussion.

ADOBE MEADOWS.

The so-called Adobe Meadows comprise 27,000 acres of mountain upland used for spring range. Dexter Creek drains the low mountains to the west, but its channel does not extend across the meadows. There is no cultivation here, and irrigation is not probable, due to uncertain and insufficient water supply and other adverse conditions.

VALLEY NORTH OF BISHOP.

The valley extending along the railroad north from Bishop is supposed to have been the original course of Owens River.[1] There is no defined stream through much of this area and the only land irrigated is supplied from small creeks. There are 77,000 acres of this agricultural land north of present canals. While canals at higher levels might be built to cover some of the southern portion, it will not be feasible to irrigate the much larger part of the area.

LONG VALLEY.

Long Valley is the upper agricultural area reported on Owens River, including 21,500 acres, of which 18,700 acres are irrigated. All land along Hot and Convict creeks which is classed as agricultural is irrigated. Along the upper river there are about 2,800 acres of agricultural land which is above present irrigation. The land is held in a few large stock ranches and irrigation consists mainly of the flooding of meadows for hay and pasture. The altitude is 6,500 to 7,000 feet and the growing season shorter than in the lower valley. The irrigation of

[1] U. S. Geol. Survey, Water Supply and Irrig. Paper No. 181.

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all agricultural land reported is feasible, but unlikely under pres general conditions. The lower end of the valley will be flooded by t proposed reservoir of the Los Angeles aqueduct.

ROUND VALLEY.

Round Valley, comprising 8,700 acres, of which 5,630 acres are ir gated, lies along Pine, Rock, and Horton creeks west of Bishop, at altitude of 4,500 to 5,000 feet. In general characteristics it is simi to the main Owens River Valley. The tributary drainage area of 1 square miles furnishes sufficient water for all the land, that remaini unirrigated being generally too rough to have made its cultivati profitable up to the present time.

OWENS RIVER VALLEY, BISHOP TO ABERDEEN.

Extending from the vicinity of Bishop to just above the diversion the Los Angeles aqueduct, near Aberdeen, is the main irrigated a of the valley. Of the 100,000 acres of agricultural land reported he 47,400 acres are irrigated under both incorporated and private can Bishop Creek as well as Owens River being used. The Nevada-Calif nia Power Company has a power plant on Bishop Creek and partia regulates its flow by storage. Principal diversions in this section by Owens River and Mesa Canal, Bishop Creek Ditch, Farmers Dit Upper McNally Ditch, Lower McNally Ditch, Rawson Ditch, Dell Dit Collins Ditch, Owens River and Big Pine Canal, Sanger Ditch, a by numerous small ditches on Bishop Creek that are within the Bis Creek Water Users' Association. Present use of water is excess and it is considered probable that by economical methods the water present diverted can be made to irrigate most of the agricultural la in this portion of the valley. More economical methods of irrigat will also do much to relieve the rise of alkali over large areas of valley land.

OWENS RIVER VALLEY, ABERDEEN TO OWENS LAKE.

From the aqueduct intake south to Owens Lake all irrigation under control of Los Angeles receives its water supply from the tri tary west-side creeks. Valley land below the aqueduct is practica controlled by Los Angeles, the city now irrigating to some ext under East Side and Stevens ditches. Surplus rights in the vari creeks are controlled by Los Angeles and increase in irrigated a will depend mainly on more economical use under present acqui rights. There are 98,000 acres of agricultural land reported in t portion of the valley of which 21,900 are irrigated at present.

OWENS RIVER VALLEY, WEST AND SOUTH OF OWENS LAKE.

Lying west of Owens Lake is a strip of agricultural land extend as far south as Olancha, containing 8,000 acres, of which 640 ac are irrigated. The water supply is derived from local creeks, the r off being less than that from similar streams farther north. Surp rights are also controlled here by the Los Angeles aqueduct and mu increase in irrigation is not probable.

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SUMMARY.

Irrigation has probably reached nearer to its ultimate acreage in this division than in the other mountain sections of the State. Present practice follows the typically wasteful methods of the mountain meadows where water is generally abundant and where the native grasses are less injured by over-use than the crops of the more intensively farmed sections. There is a total of 472,000 acres of agricultural land reported that is topographically suited for irrigation, with 137,760 acres irrigated in 1911. In Alpine County, and Antelope and Bridgeport valleys, but a small portion of the agricultural area is unirrigated and the water supply is sufficient for the whole. The area southwest and northwest of Mono Lake should be capable of considerable increase in irrigated area if better transportation is provided. The areas northeast of Mono Lake and Adobe Meadows present but little possibility for irrigation and their inclusion in the classification of this report may be questioned. In the valley areas in the Owens River drainage a variety of conditions exist. In Long and Round valleys but little increase in irrigated area is to be expected as, while the water supply can be made to also serve the unirrigated agricultural land, the best of the meadow lands are already improved. In the area extending north from Bishop but little irrigation is probable except on such land as may be covered in the southern portion by higher Owens River diversions. In Owens Valley, extending from Bishop to Olancha, increase in irrigated area will come most largely through the more economical use of present acquired rights. Ultimately it may develop that it will be practicable to store water for local use in excess of the requirements of the Los Angeles aqueduct. Considering this division as a whole the increase of irrigated area from the present 137,760 acres to 200,000 acres would seem to be feasible, and ultimately, if more intensive cultivation of crops of higher return should become established, even this figure may be exceeded. The increasing injury of lower lands by over-irrigation, which is so noticeable at present, must be remedied, however, before a higher agricultural development can be expected.

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SUMMARY FOR CENTRAL CALIFORNIA.

The following table resummarizes the agricultural and irrigated areas of central California and gives the areas it is estimated will eventually be irrigated in each main divison:

Summary of agricultural, irrigated, and estimated irrigable areas in central California.

Division.	Total areas of valley agricultural land. Acres.	Total areas of valley plains. Acres.	Total areas of foothill agricultural land. Acres.	Total areas at present irrigated. Acres.	Estimated area which will ultimately be irrigated. Acres.
Coastal valleys	887,000	----------	----------	82,000	200,000
San Joaquin Valley	6,530,000	1,046,000	----------	1,728,975	3,850,000
Sierra foothills above San Joaquin Valley	----------	----------	730,000	10,620	50,000
East of Sierra Nevada	472,000	----------	----------	137,760	200,000
Totals	7,889,000	1,046,000	730,000	1,959,355	4,300,000

The standards adopted for the classification of the irrigable agricultural land and the present irrigated area are given in the introduction. The estimated areas which may ultimately be irrigated are discussed under each division and are based on consideration of all available information as to water supply, topography, soils, etc. While required information concerning many areas is at least partially lacking and present developments in many cases are not sufficiently complete to form the basis for an estimate of the total resources, yet it is believed that the total figures given for each of the four main divisions are fairly representative of their irrigation possibilities, and while their attainment may require a long continuation of the present rate of progress and may be retarded by present conflicting interests and lack of adequate legal control, eventually the financial returns from irrigation should force the fullest use of all available resources. The generally fair returns obtainable without irrigation in the coast valleys may make the full development slower in that portion, yet the high value of the agricultural products will justify the use of any methods which will increase the yields. In San Joaquin Valley the present rate of increase in irrigation is sufficiently rapid to furnish irrigated lands for all the new settlers who are being secured, and the construction of further systems can be expected to keep pace with the colonization demands. In the Sierra foothills increase will be slower due to the lack of transportation facilities and to the smallness of the separate areas. In the lands east of the Sierra increase in area will result from a more economical use of present supplies. With an area irrigated at present of 1,964,355 acres and with over 2,300,000 acres more whose irrigation can be considered feasible, the importance of any factors which materially influence the increase in use of these resources cannot be questioned. When the full significance of the population and the auxiliary industries which will be supported by such a development as it is reasonable to expect is appreciated, the direct interest of the State in all the problems of this development can be readily realized.

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IRRIGATION RESOURCES OF SOUTHERN CALIFORNIA.

By C. E. TAIT,

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INTRODUCTION.

The belief that the water resources of southern California are completely developed and used is erroneous. This is true for limited areas only. The waters of southern California are more fully used than those of the northern and central portions of the State or than those of other states, but development is not measured by the same standards as elsewhere. The highest duty of water, the most efficient and costly systems for transmission and distribution, and the most economical methods of application generally to be found in the irrigated sections of the United States are in this region. The agricultural industries include many of those prominent throughout the West, such as growing of alfalfa, grain, sugar beets, and deciduous fruits, the raising of live stock, dairying, and in addition, the growing of crops restricted to the semi-tropical climate of the Southwest, such as citrus fruits, English walnuts, olives, and Lima beans.

It is sufficient to say regarding lands that more territory remains unclaimed than water can ever be made available for and that these comprise areas where soil and climate are as favorable to agriculture as the best lands now being irrigated. The accompanying map shows the areas of agricultural and irrigated land, together with the more important irrigation canals. Practically all valley and agricultural land within the coastal drainage was formerly, and much of it is yet, embraced in Spanish grants. Under such condition, speculation in land begins with settlement. Nearly all of the deserts were originally Government land and settlement is under the national land laws.

Practically all reclamation has been by private enterprise. The most popular form of organization for the control and management of irrigation systems is the mutual water company, formed by landowners to provide water for their own use, and not for sale and profit. The area reclaimed by the Government is 16,500 acres and that irrigated under state irrigation districts is 15,500 acres.

A conspicuous feature of irrigation development in southern California is its rapidity, the water resources having been developed in spite of uncertainties regarding rights to use water. Storage has been discouraged more than other kinds of development, owing to the difficulty in determining the effect of storage in the mountains on pumping underground waters in lower basins. Investors have been willing to take chances on entering upon litigation and they have in many cases constructed works where it was known that litigation was inevitable.

While construction of irrigation works has been rapid, settlement of lands has kept pace with or been in advance of construction, and

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in this respect southern California is an exception to the general rul throughout the West. The experience has been the same on the coas and on the desert, whether the lands were public or private.

The development of electrical power has not been detrimental to irri gation in southern California, as power plants are usually located i mountain canyons above diversions for irrigation. In some cases th use of the water for power is beneficial in preventing loss by conveyanc in pipes that would otherwise occur in the stream channels.

The surface waters were the first to be used. Pumping of under ground waters then began in the older districts and portions of th flood waters were stored. The greatest activity in late years has bee in pumping from wells. A great increase in irrigation is still possibl from pumping and it remains for the flood waters to be much mor completely conserved for the highest development of southern Cali fornia's irrigation resources.

SANTA BARBARA AND VENTURA COUNTIES.

These are counties that have not so completely used their wate resources as some others in the southern end of the State. This condi tion is accounted for in part by the fact that irrigation there is no altogether necessary for the successful production of crops. Thi division, and Santa Barbara County especially, in former years wa one of less industrial activity than were the districts farther south The owners of Spanish grants and large tracts have been slower t dispense with the comparatively free and independent life of grai growing and ranching on a large scale for the lure of greater financia profit in subdividing properties for sale and intensive culture. In thi respect, this section partakes somewhat of the conditions in some of th large valleys of the northern and central parts of the State.

While it is true that very fair crops are secured in the moist atmos phere of the coast valleys, there is no longer doubt of the advantag of irrigation in either of the two counties. Formerly it was believe that English walnuts, near Santa Barbara, were better unirrigated but experiments within the last few years have shown that the increase production and profits from irrigating the orchards more than compen sate for the cost of irrigation. Even some oranges were grown withou irrigation, and lemons alone were regarded as being unprofitable with out water. With the success of the lemon industry has come increase interest in irrigation. Grain ranches and bean fields, even thoug beans themselves give good returns, are being replaced by lemo orchards where water can be secured for irrigation.

Development in Santa Barbara and Ventura counties depends largel upon the storage of flood waters. The first movement for storage wil no doubt be taken by the city of Santa Barbara, owing to the need fo more water for future growth. Santa Maria and Santa Clara Rive valleys and the Oxnard Coastal Plain are large areas where muc extension of irrigation should result from pumping and storage.

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SANTA MARIA VALLEY.

Santa Maria River flows westward to the Pacific coast, forming the boundary between San Luis Obispo and Santa Barbara counties. Nearly all the valley lies south of the river and in Santa Barbara County. The lower 15 miles of the river traverses Santa Maria Valley. The river's chief tributary, the Sisquoc, enters the valley at its extreme eastern end and joins the main stream on the south side.

Santa Maria Valley contains 147,000 acres of agricultural land, of which 11,441 acres are now irrigated. Most of the land holdings are from 80 to 160 acres, although there are a number of holdings exceeding 1,000 acres. Apparently the land has been formed by débris of the river filling a bay of the ocean. Some alkali is present near the coast, but much of this land may be reclaimed by drainage. A local sugar company is at present dredging a 20-foot open drain near the mouth of the Santa Maria which will reclaim about 1,000 acres of land now too moist for agricultural purposes, and has already drained 250 acres near Oso Flaco. This company also contemplates the drainage of 275 acres near Guadalupe in the western end of the valley.

Irrigation has not been regarded as necessary in this section and the water resources have not been very fully developed. Grain, lima beans, corn, and to some extent sugar beets have been grown successfully without irrigation. The sugar company supplies water to about 7,000 acres of land in the lower portion of the valley by pumping from wells and from Guadalupe Lake, a small body of water south of the river and having no connection with it and no outlet to the sea. This company also diverts water from the river in the upper portion of the valley. The Santa Maria Water Company takes water from the river for a small tract of alfalfa east of Santa Maria. The Sisquoc Water Company diverts water from the Santa Maria for the irrigation of alfalfa by means of a submerged dam. In addition to the crops already mentioned some deciduous fruits and garden truck are irrigated. Sugar beets are given one irrigation only, this occurring when the crop is about two and one half months old. Approximately 1 acre-foot per acre is used in the irrigation of sugar beets. The Union Sugar Company gives the cost of pumping water for this one irrigation from $2.80 to $3.77 per acre and the cost of water diverted from the stream about $1 per acre, also the cost of applying water from $2.50 to $4 per acre.

That portion of the Santa Maria above its junction with the Sisquoc is known as Cuyama River. This stream traverses mountain country throughout its entire course excepting one basin situated 30 miles back from the Pacific coast at an elevation of 2,200 feet known as Cuyama Valley. This basin includes 45,000 acres of agricultural and grazing land. Some grain is grown in the upper end of the valley but the greater part is devoted to grazing. The only irrigated land is one small tract in alfalfa supplied with water pumped from the river. Land holdings are large. Cuyama Valley is not reached by railroad.

The only available measurements of the Santa Maria are of 1904 and

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1905. These are incomplete but show the discharge above the Sisquoc for 1905 to be about 61,000 acre-feet.[1] The watershed of the Santa Maria is 1,050 square miles and of the Sisquoc 530 square miles. The mean annual rainfall at Santa Maria for a 25-year period is 14.34 inches and is is probably 20 to 25 inches in the mountains where the elevations range from 500 to 6,500 feet above sea level. The river is subject to floods in winter and spring but becomes very low in summer. It is probable that further development may take place as result of storage of flood waters, although there is no definite knowledge of suitable reservoir sites. Santa Maria Valley is underlaid with an abundant supply of underground water as shown by wells already drilled and a large increase in irrigation should come from this source. Water stands in wells at depths of 15 to 30 feet in the lower part of the valley and at greater depths in the upper part. Practically all land in the valley should eventually be irrigated.

SAN ANTONIO AND LOS ALAMOS VALLEYS.

San Antonio Creek is the next stream south of the Santa Maria. It traverses in its middle course for a distance of 10 miles a long, narrow valley, the upper portion of which is known as Los Alamos and the lower San Antonio. Los Alamos and San Antonio valleys have an area of 15,800 acres. Large land holdings are an obstacle to rapid development by irrigation. There is very little irrigation on San Antonio Creek aside from the sugar beets of the Union Sugar Company of which there are 1,000 acres in Los Alamos Valley and 750 acres in San Antonio Valley. The beets are irrigated principally by pumping from wells but some of the water for those in San Antonio Valley is diverted from the creek. The surface flow of the creek during the irrigating season is small and the principal source of water must be the underground supply which appears to be plentiful. The watershed of San Antonio Creek is 140 square miles in area and the highest portions reach elevations of only about 1,500 feet. The watershed is of less value as a water producer than its area would indicate. No measurements of San Antonio Creek are available but its discharge is small. It is hardly probable that the irrigated area will exceed 5,000 acres.

SANTA YNEZ AND LOMPOC VALLEYS.

Santa Ynez River is the largest stream wholly within Santa Barbara County. It has a total length of 70 miles and flows westward to the Pacific, paralleling Santa Barbara Channel and being distant from it only 5 or 6 miles. The crest of the Santa Ynéz range forms the dividing line between the drainage of the river and that to the Santa Barbara coast on the south. The principal tributaries enter the Santa Ynez from the north, draining a mountainous country which is an extension of the Coast Range. Practically all the valley land bordering the Santa Ynez is on the lower 18 miles of the river. There are two main basins, the lower one touching the coast and known as

[1] U. S. Geol. Survey, Water Supply and Irrig. Paper No. 177.

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Lompoc Valley, and the upper one being separated from it by the Santa Rita hills and known as Santa Ynez Valley.

Lompoc Valley contains 29,300 acres of agricultural land of which only 1,590 acres are irrigated. Both heavy and light soils are found. The crops grown include mustard, grain, sugar beets, lima beans, onions, garden truck, and deciduous fruit. The rainfall at Lompoc is about 16 inches which, together with the moist atmosphere of the coast, permits crops to be grown without irrigation with fair results, so that land owners have been somewhat indifferent to irrigation development. The Union Sugar Company irrigates about 1,000 acres of beets by pumping from wells and from a stream. A few small tracts are irrigated from pumping plants. At one time plans were made to irrigate both sides of the valley from a dam on the river two and one half miles above Lompoc. Wells are from 30 to 70 feet in depth and the pumping lifts are low. Near the coast wells from 60 to 70 feet in depth flow. Santa Rita Valley is an eastern extension of Lompoc Valley. Burton Mesa borders the ocean north of Santa Ynez River and is devoted to grain growing and grazing.

Santa Ynez Valley has an area of 29,000 acres of land that may be classed as agricultural. The land is held principally in large tracts and grain growing and grazing are the main industries. About 60 acres of the Indian reservation near Santa Ynez is irrigated with water from Santa Cota Creek, and 25 acres of alfalfa near Los Olivas is supplied with water by pumping from a well. Plans are being made to irrigate 200 acres by pumping from wells. Underground water stands at a depth of 10 to 20 feet and a number of small wells are drilled 30 to 100 feet deep.

All of the discharge of the river in the dry season is claimed and used. The greater part of the watershed of the river is within the Santa Barbara national forest reserve. The precipitation varies from 20 to 25 inches throughout the watershed. Light snows lie on the higher peaks in the winter and spring. Measurements of the river near Lompoc from 1906 to 1910 show a mean annual discharge of 167,000 acre-feet.[1] The watershed above Lompoc is 785 square miles and the mean annual rainfall is estimated at 25 inches. Several good storage sites are located on the upper river and its tributaries, but it is probable that one or more of these will be utilized for the benefit of Santa Barbara by carrying the water through the Santa Ynez Range by tunnel. A considerable portion of Lompoc and Santa Ynez valleys may be irrigated from underground waters and the flood waters if stored and used in these valleys would be sufficient for all the remaining land.

SANTA BARBARA COASTAL PLAIN.

The Coastal Plain bordering Santa Barbara Channel has a southern exposure and stretches from Naples to Carpinteria with a total length of 30 miles and a width of from one half to three miles. Back of the plain is Santa Ynez Range. The plain is divided by hills into four

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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parts. Beginning at the west these are: Goleta Valley, Santa Barbara, Montecito, and Carpinteria Valley. The entire coastal plain embraces 30,750 acres of agricultural land including 450 acres irrigated, together with other small tracts of irrigated land, the exact area of which is not known. This is a section of natural beauty, the valleys being broken by hills dotted with live oak and bordered with sand dunes along the coast. The climate of Santa Barbara is tempered by the sea and very equable. The winds are moderated by the mountains and by the Catalina Islands across the channel. The valleys are rolling and the soil varies in character from heavy loam to light sandy soil. Bays of the ocean once extended into each of the chief basins, these having now been filled by marine deposits and stream alluvium. This filling still continues at such places as Carpinteria and Goleta landing. Land bordering the sea marshes is strongly impregnated with alkali and will not have agricultural value for many years to come. Much of the land is held in tracts of from 5 to 40 acres, the small holdings being in orchard. There are some large holdings of several hundred acres devoted to grain growing in Goleta Valley.

The chief crops are English walnuts, lemons, oranges, olives, apricots, figs, lima beans, and grain. This is a section where irrigation has not been been considered necessary for successful farming, although there is a growing belief that an increase in production in some crops, such as English walnuts and deciduous fruits, can be secured by irrigation that will more than justify the cost of applying the water. No attempt has been made to grow lemons without irrigation and most of the oranges are irrigated, although but few oranges are grown. The mean annual precipitation at Santa Barbara for forty-three years is 17.32 inches. While the rainfall is not much greater than for other localities farther south and inland where irrigation is very necessary, it has a better distribution. This with a moist atmosphere and mild climate produces luxuriant vegetation. The success now being had with lemons is prompting the conversion of much of the grain and bean land into lemon orchards, although lima beans themselves have given good profit in late years. Lemons are irrigated four times in a season, oranges three times, and walnuts once in the few places where they have been irrigated at all. Strawberries and garden truck are irrigated where grown. Where walnuts have been irrigated the results have proven beyond doubt the value of irrigating them. The duty of water near Santa Barbara is a little higher than in the fruit districts farther south and inland, and 1 miner's inch serves 10 acres of citrus fruit while walnuts and deciduous fruits require less water.

The numerous streams draining the southern slope of the Santa Ynez Range are short with small drainage basins and rapid fall. They are torrential following rains and the discharge becomes very low in the summer. The total watershed contributing to the coastal plain is about 100 square miles. The hills and mountains are covered with a thick mat of brush with a little timber on the higher peaks. Few of the streams

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have well-defined channels across the valley owing to the water all being absorbed by the sands except for short periods in the rainy season.

The following streams drain to Goleta Valley: Tecolote, Winchester, Elwood, Glen Anne, Bartlett, and San Pedro, Las Vegas and San José creeks, Maria Ygnacio Canyon, San Antonio Creek, Arroyo Burro, and Alascadero Creek. Of the foregoing Maria Ygnacio is the most important stream. The streams leading to Santa Barbara are: San Roque, Diablo, Mission, Rattlesnake, and Sycamore canyons. Those draining to Montecito are: Cold Spring, Dinsmore, and Romero canyons and Ficay Creek. The streams discharging into Carpinteria Valley are: Toro Canyon, Arroyo Parida, Santa Monica, Franklin, and Sutton canyons, Carpinteria and Gobernador creeks and Rincon Canyon.

All of the surface water of the streams is used for irrigation during the summer. Water is diverted through small ditches and pipe lines. An idea of the size of these streams may be gained by the measurements of Mission Creek, one of the larger streams. These show extremes of 02 and 2.80 cubic feet per second from 1888 to 1903, inclusive.[1] Mission Creek has been one of the sources of supply for the city of Santa Barbara. The city also secures water from a tunnel 5,080 feet long in Cold Spring Canyon. The tunnel is closed by a bulkhead in the winter until a head of over 100 feet is raised over the outlet. On being opened it delivers 1 cubic foot per second for three months in the dry season. The city recently completed its Mission Canyon tunnel, 19,560 feet in length, extending entirely through the Santa Ynez Range, with the north portal in position to receive water from Santa Ynez River and from one or more protected reservoirs on this stream. The discharge of Mission tunnel in 1910 varied from 2.42 to 5.18 cubic feet per second. Several small privately owned tunnels collect water from Sycamore and Franklin canyons and Arroyo Burro. Much of the water used in this section is secured from wells, some of which flow. The city supplements its domestic supply from Mission Creek and tunnels by pumping the De La Garra wells, seven in number, and with depths from 200 to 700 feet. Wells in Goleta Valley are usually from 80 to 100 feet in depth. Cienagas lie back of low hills in Goleta Valley, where the pumping lift in wells is not over 20 feet. Water can be pumped with gasoline engines for $.0075 per miner's inch per hour. Some wells near Montecito are from 1,000 and 1,400 feet in depth and others in the gravels along the stream are from 100 to 300 feet in depth. Wells at Carpinteria 200 feet deep produce salt water unfit for irrigation, indicating that the source is the sea, while wells only 50 feet deep in the same locality furnish fresh water. It is possible that wells could be drilled through the salt water to penetrate the same strata found in the mountains, in which case fresh water should be secured. There are artesian wells near Carpinteria about 140 feet deep. A large portion of the coastal plain can be supplied with water for irrigation by wells.

[1] U. S. Geol. Survey, Water Supply and Irrig. Paper No. 116.

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The fall of the mountain streams on the south side of the Santa Yn is so great that there are few opportunities for storage. Gobernad Creek is said to have a reservoir site, but it is doubtful if there is enou water for storage. As the grain lands are converted into walnut a citrus orchards water will be required to produce the best results. T construction of Mission tunnel by Santa Barbara leaves the city in position to carry out a comprehensive plan for storing the flood wate of the Santa Ynez and conducting them through the range. The hi cost of the tunnel has had a tendency to discourage, for the time bein further investment for storage works, but it seems certain that th opportunity for a water supply will eventually be taken advantage The flood waters of Santa Ynez River would, in addition to supplyi the city, furnish water for the irrigation of considerable agricultu land. Water has such a high value at Santa Barbara that the ci should be able to withstand an unusually high expense for storage. miner's inch or the one-fiftieth of a cubic foot per second of water flo ing continuously at Montecito sold for $4,000 and some of the water h a much higher value for irrigation and domestic use on suburban estat The plan involves the construction of Gibraltar reservoir to be locat on the Santa Ynez below the junction with Mono Creek. Another si that has received serious consideration is on Mono Creek, the chief trib tary of the river. Several other reservoir sites are located on the ma river and tributaries. For the complete and best utilization of the flo waters storage must be provided to hold over water from years of hi flood for use in the dry years. The Gibraltar site is most likely to first utilized, although the discharge of the river should justify the fir construction of supplemental reservoirs at one or more of the other sit A 100-foot dam at Gibraltar would store 6,480 acre-feet while a dam 1 feet high would give a capacity of 15,793 acre-feet.[1] A 100-foot dam the Mono site would give a capacity of 8,763 acre-feet. Measuremer of the Santa Ynez at the Gibraltar dam site from 1906 to 1910 show mean annual discharge of 94,000 acre-feet. The watershed above th site is 207 square miles. The reservoirs, if constructed, would be p marily for Santa Barbara, but some water should be available for irrig tion and practically the entire coastal plain should eventually irrigated from reservoirs and wells.

VENTURA AND OJAI VALLEYS.

The Spanish name, San Buenaventura, is usually shortened to Ve tura in speaking of the city, river, and valley to which the original nar was applied. The headwaters of Ventura River are collected into Oj Valley and adjoining territory. This upper basin is drained to t Pacific through a narrow valley seven miles in length known as Ventu Valley.

[1]U. S. Geol. Survey, Water Supply and Irrig. Paper No. 116.

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VENTURA VALLEY.

Ventura Valley has 3,700 acres of agricultural land of which 1,180 acres are irrigated. The crops consist chiefly of citrus and deciduous fruits, walnuts, olives, figs, alfalfa, and grain. The city of Ventura is located between mountain and sea at the mouth of the river. The valley is widest adjacent to the city where the width is only one and one half miles. Conditions in general are quite similar to those near Santa Barbara, irrigation not being absolutely necessary to the growing of crops. The mean annual rainfall at Ventura for a period of twenty years is 16 inches. The principal diversions from Ventura River are those of the Ventura Power Company which operates two small canals.

OJAI VALLEY.

The name Ojai is derived from the Indian and means "nest." It well describes this mountain valley. Live oak and ivy abound in the valley and on the surrounding hills. The valley is 12 miles back from the Pacific coast, and Nordhoff, centrally located in the basin, is 750 feet above sea level. The valley contains 11,300 acres of agricultural land, of which 850 acres, mostly above Nordhoff, is irrigated. Crops include citrus fruits, almonds, apricots, apples, grapes, alfalfa, and grain. The land is held in farms of generally less than 40 acres when in orchard but larger when in grain. Numerous pumping plants supply water for the irrigation of orchards and small tracts and the San Antonio Water Company takes water from San Antonio Creek, a tributary of Ventura River, for use in the upper part of the valley. All of the surface flow during the irrigating season is used but large quantities of flood waters run to the sea during the winter season. The Matilija reservoir site is located on the creek by that name which is one of the chief tributaries of the river. Water stored here could be conveyed to lands in Ventura Valley or the lower portion of Ojai Valley.

Ventura River has a watershed of 190 square miles. The run-off is estimated at .15 cubic feet per second per square mile giving a mean discharge of 28 cubic feet per second. The flow becomes very low in the fall and any large extension of irrigation depends on storage. Some increase is expected from additional pumping plants in Ojai Valley.

UPPER OJAI VALLEY.

Upper Ojai Valley is at an elevation of 1,500 feet on the divide between Ventura River and Santa Paula Creek. It has an area of 1,900 acres of rolling land. It is divided from Ojai Valley by hills. The greater portion is drained to San Antonio Creek and Ventura River. The Upper Ojai Valley is less developed than Ojai Valley and the conditions for agriculture are not quite so favorable as in the larger and lower basin. The winter temperatures are too low to permit citrus fruit culture and aside from a few apricots and apples grain is the only crop. There is little or no irrigation and the extent of the underground water supply is undetermined. Water is secured from wells for domestic purposes. The upper end of the valley is productive of oil. The water-

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shed tributary to the Upper Ojai is 27 square miles in area. No reliable estimate can be formed as to the probable future development as no knowledge is at hand regarding available storage sites and it is more probable that the flood waters, if conserved, would be used along Santa Clara River.

SANTA CLARA RIVER VALLEY.

Santa Clara Valley of Ventura County should not be confused with the valley of the same name lying just south of San Francisco Bay. Santa Clara River is the largest and most important stream in Ventura County. It is formed by the junction of Laguna and San Francisquito canyons in the northwestern portion of Los Angeles County. The Santa Clara flows westerly from this junction and soon enters Ventura County and discharges into the Pacific between the cities of Oxnard and Ventura. The Santa Clara has no tributaries of consequence from the south, but three large streams, viz., Santa Paula, Sespe, and Piru creeks, from the north, drain a larger mountain territory than the main river itself. The valley is 40 miles long and gradually widens toward the west until the open coastal plain, being the delta of the river, is reached. The valley contains a total of 120,800 acres of land suitable for agricultural purposes and of this 31,020 acres are now irrigated.

All of the usual varieties of soils are found in Santa Clara Valley. In the coastal plain the soil is generally heavy while in Santa Clara Valley proper the heavy soil is confined to the low lands bordering the river. The higher lands are sandy and close to the foothills the material is very coarse and many boulders are found. Alkali is present in large quantities in the lands bordering the coast and is also found in the low lands along the river. The greater part of the irrigated land is in the central portion of the valley about the towns of Piru, Fillmore, Santa Paula, and Saticoy. The irrigated crops include oranges, lemons, English walnuts, deciduous fruits, grapes, alfalfa, beans, and garden truck, while sugar beets are grown usually without irrigation. Some grain is also produced but never irrigated. Lima beans constitute the largest crop, there being an annual production of about 63 million pounds, more than one half of the world's lima bean supply. Sugar beets also occupy a large acreage on the coastal plain, the product being taken to Oxnard for manufacture. Beets are grown on land strongly alkaline. They are usually planted early so that the tops shade the ground by the time hot weather begins, thus preventing excessive evaporation of moisture from the soil and the concentration of salts at the surface. In general beans are grown on land a little higher than the beet lands. Beets are not irrigated except in very dry years, when in some cases a little water has been supplied.

At the head of the delta of the Santa Clara is the town of Saticoy, the center of a section where deciduous fruits and English walnuts predominate. Apricots lead among the fruits, but a variety is grown. In the middle portion of the valley, about Santa Paula, Fillmore, and Piru, there are many orchards, but the crops are much diversified. This

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ection is adapted to lemons and some valuable lemon orchards are in he vicinity of Santa Paula. On some of the low land suitable for the rowing of citrus fruits located close to the foothills the removal of rush and boulders is costly, but it is being cleared very rapidly for the etting of lemon trees. In the extreme upper portion of the valley, in os Angeles County, there is little or no irrigation, practically all of the and being used for grain and grazing.

All of the summer discharge of Santa Clara River is taken out for rrigation and about forty pumping plants take water from wells. Diversion from the river is made by ditches and pipe lines, no attempt being made, as a rule, to install permanent dams or headworks on account of the torrential character of the stream, but temporary dams are constructed at the beginning of each irrigation season with the expectation that they will not remain through the winter. A few pumping plants are located near Fillmore and Santa Paula and more on the north side of the river near Saticoy. Some of the wells in this section flow. The following companies supply water in Santa Clara Valley:

Companies supplying water in Santa Clara River Valley, 1909.

Name.	Source of supply.
De Valle Company	Santa Clara River.
Piru Water Company	Piru Creek.
South Side Improvement Company	Santa Clara River and wells.
Sespe Land and Water Company	Sespe Creek and well.
Fillmore Irrigation Company	Sespe Creek.
Interurban Land and Water Company	Santa Clara River.
Turner Ditch	Santa Clara River.
Santa Clara Water and Irrigation Company	Santa Clara River.
Vineyard Ditch Company	Santa Clara River.
Santa Paula Water Works	Santa Paula Creek.
Thermal Belt Water Company	Santa Paula Creek and Santa Clara River.
Cerurga Water Company	Well.
Saticoy Irrigation Company	Wells.
Saticoy Water Company	Flowing wells.
Montalvo Irrigation Company	Well.

The distributing systems for orchards are of concrete pipe laid underground and those for flooding consist of open, unlined ditches. The quantity of water used varies greatly. Citrus orchards are usually irrigated every four or five weeks from May until September, inclusive, 1 miner's inch being sufficient for from 5 to 10 acres. The quantity of water applied to orchards under pumping plants does not exceed 1 acre-foot per acre, but under the ditches the duty is from 1 to 2 acre-feet per acre. Deciduous fruits, including English walnuts, are irrigated with less regularity than citrus fruits and require less water. Alfalfa is irrigated once after each cutting except the last and is given 3 acre-feet or more per acre each year. Sugar beets are sometimes irrigated once before they are up and once afterwards, although their irrigation depends much on the character of the land.

The mean annual rainfall for the valley as shown by records at Oxnard and Santa Paula is about 16 inches. Winds blow inland from the coast daily throughout the summer tempering the heat of the valley. In the winter the direction of the movement of air is often

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reversed when winds sweep down through the valley, often with disagre able effect but sometimes preventing much damage to citrus fruits b frost. The idea has prevailed in Ventura County, especially on th coastal plain, as it has in Santa Barbara County, that irrigation is n necessary and the success of the lima bean industry without irrigatio has done much to divert attention from the development of the wat resources of the county. Within the last few years more interest ha been taken in irrigation through the belief that the lands now givin fair profit without water would yield a much larger one if irrigate The principal development taking place at the present time consis in the installation of private pumping plants. The underground wat of both delta and valley is very extensive and a very large portion o the land could be supplied from this source. Where flowing wel can be secured it is usually necessary to bore only about 200 feet i depth. Water can be secured in nearly any part of the valley a less than 50 feet and near the coast sometimes at less than 10 fe below the surface. Much of the land about Oxnard requires drainag for the highest development and comparatively small portions hav already been tile drained.

As the lands near the coast become less moist it is probable tha higher-priced crops will be grown on them and these in time wi require irrigation. If the water be supplied by pumping from well with a corresponding general lowering of the water plane, the lowe lands will be further dried and gradually the entire section ma become irrigated, as has been the case in a number of other similarl located sections in the southern part of the State.

The utilization of all the underground water of the valley, togeth with the conservation of the flood waters of the main stream or i tributaries, would furnish all the water necessary for the irrigation o every acre of valley land. A reservoir site on Sespe Creek near i mouth has been examined by engineers and pronounced feasible fo the storage of flood waters. It is probable that other reservoir sit exist in such a large area of mountainous country. The drainage basi of the Santa Clara is 1,576 square miles in area, the larger portion o which is from 4,000 to 7,000 feet above sea level. The three mai tributaries are very torrential. Much water sinks on reaching th valley and underground water is so abundant that pumping has ha little effect on the level.

Measurements of Santa Clara River at a point above Santa Pau made in June, July, August, and September, 1903, indicate that th summer flow of the river varied from 30 to 45 cubic feet per secon The river was discharging 127 cubic feet per second when measure in May of the same year.[1] The run-off of the Santa Clara is estimate at not less than 200,000 acre-feet, which is sufficient for all of th unirrigated valley land.

[1]U. S. Geol. Survey, Water Supply and Irrig. Paper No. 184.

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SIMI AND LAS POSAS VALLEYS.

Simi, Little Simi, and Las Posas valleys are situated south of Santa Clara Valley along a stream which is dry the greater part of the year nd which is known as Arroyo Simi in its upper course and Arroyo as Posas in the lower. The Arroyo joins Calleguas Creek, which mpties into the Pacific at Mugu Laguna. Simi Valley, which is the pper one of the three basins, is separated from San Fernando Valley n Los Angeles County by the Santa Susana pass. The basin contains 3,900 acres of cultivable land, of which 530 acres are now irrigated. The Little Simi is west of and below Simi Valley. It contains 13,500 cres of valley land of which 600 acres are irrigated. Las Posas Valley, he lower one of the three basins, opens to the coastal plain about the ity of Oxnard. It contains 32,300 acres of agricultural land. Connejo Valley is situated in the hills south of the Little Simi at an elevation f about 1,000 feet and has an area of 15,000 acres devoted entirely o grazing and stock raising.

Conditions in the three main valleys on the arroyo are very similar. The farms vary from 40 acres to several hundred acres, the larger ones eing parts of ranches of several thousand acres extending into the ills and mountains. Crops grown include grain, beets, deciduous ruits, alfalfa, and some grapes in the Little Simi. The principal crop n Las Posas Valley is lima beans although there is a little deciduous rchard. Underground water conditions are fairly good in Simi Valley nd wells bored to a depth of 80 feet in the lower portion flow. Where he flow is light pumps are used to increase the discharge. The under- round water is apparently not so extensive in the Little Simi and ells must be pumped. Ground water is found at depths of 60 to 100 eet in Las Posas Valley, most of the wells being for domestic use.

An irrigation system has been planned for Little Simi Valley to be perated by a mutual company of land owners, the water to be secured rom wells in the upper part of the basin. In a well 90 feet deep in his locality water stands at 10 feet beneath the surface. The water s to be used on about 300 acres located principally below Moorpark. The hills surrounding the valleys are low and some of them are denuded of brush and are used for grazing. The arroyo and its ributaries discharge no water on the surface except for short periods ollowing storms and development of valleys by irrigation depends lmost entirely on underground water. It is possible that the western portion of Las Posas Valley, sometimes called Pleasant Valley, might e supplied with water from Santa Clara River brought around the oint of the hills at Springville, provided all of the water is not needed n the Santa Clara. The irrigated area should be doubled by pumping.

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Summary for Santa Barbara and Ventura counties.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
Santa Maria and Cuyama valleys	192,000	11,441	140,000	Storage on Santa Maria and Sisq rivers and underground waters.
San Antonio and Los Alamos valleys	15,800	1,750	5,000	Underground waters.
Santa Ynez and Lompoc valleys	58,300	1,675	25,000	Storage on Santa Ynez River and butaries and underground wat
Santa Barbara coastal plain	30,750	600	25,000	Storage on Santa Ynez River and butaries and underground wat
Ventura and Ojai valleys	16,900	2,040	5,500	Storage on Matilija Creek and un ground waters.
Santa Clara River Valley	120,800	31,020	120,000	Storage on tributaries of Sa Clara River and undergro waters.
Simi and Las Posas valleys	74,700	1,130	2,000	Underground waters.
Totals	509,250	49,656	322,500	

LOS ANGELES AND SAN GABRIEL RIVER LANDS.

These lands are considered together, not so much because the strea supply the same underground water basin underlying the coastal pl as on account of other conditions which they have in common. T division, together with the territory of Santa Ana River, constitu the principal belt of southern California's coastal drainage, but continued development depends upon some events that do not aff lands on the Santa Ana. All parts of this division, San Fernan Valley, San Gabriel Valley, and coastal plain, may receive water fr another watershed. The Los Angeles aqueduct, costing $23,000,0 will deliver water by 1913 from Owens River, 270 miles distant, irrigation at the rate of 360 cubic feet per second, or enough to ir gate over 100,000 acres of orchard, for use on land adjoining the c limits.

Water rights on Los Angeles River have been on a somewhat differ basis from those on other streams, due to the city's pueblo rig strengthened by the superiority of domestic over agricultural a mechanical uses.

Land values throughout this division are influenced by the grow of Los Angeles and its suburbs, and the excellent county roads a network of electrical railroad lines extending from the city in directions. In some areas, as for example near Pasadena, land t meets all the ordinary requirements for agricultural use has not b given such classification, because present indications are that it w be used for suburban residence instead of for agricultural purposes.

Flood waters have not been stored in the mountains, but prepa tions are being made for impounding the headwaters of Los Ange River and similar improvements are expected in time on the S Gabriel.

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SAN FERNANDO VALLEY.

San Fernando Valley is a basin 101,150 acres in extent, lying north and west of the city of Los Angeles. A narrow strip of land back of Verdugo hills and connected to the main valley at Verdugo and Tejunga canyons adds 9,350 acres to the agricultural area. The San Rafael hills divide the basin from San Gabriel Valley on the southeast. There is comparatively little drainage to San Fernando Valley from the south, west, and northwest. Numerous small creeks rise in the mountains and hills but they are dry throughout most of the year and their channels disappear altogether on reaching the valley. Brown's Canyon is the largest of these streams. The western extension of the San Gabriel Range is drained by Tejunga River, the Little Tejunga, and Pacoima Creek into the valley from the northeast. An extensive débris fan spreads across San Fernando Valley below Big and Little Tejunga canyons. All waters at ordinary states of the river disappear on reaching the valley. The waters entering San Fernando Valley from all sides and disappearing in the sands and gravels are brought to the surface in the lower and southern part of the valley, giving rise to Los Angeles River. This stream finds an outlet toward the Pacific through the narrows just above the city where the entire drainage of the valley is forced to pass either on the surface or as subterranean flow, making a very favorable condition for the recovery of underground water.

The floor of San Fernando Valley is a broad plain of gentle slope with some rolling land on the borders. The land in its natural state is covered with a sparse growth of cactus, sage, and chaparral, with some willow along Los Angeles River. The soil varies in hardness but the greater portion of the valley is sandy or gravelly loam. Some adobe is found near the southern hills while a sandy silt soil borders the lower course of Los Angeles River. About 10,000 acres of Tejunga and Pacoima washes lined with gravel and cobble must be considered uncultivable unless it is demonstrated that it is adapted to fruits or other crops high enough in value to justify clearing. The general slope of the land in the western portion of the valley is from 40 to 50 feet per mile but in the eastern portion the slopes reach 200 feet per mile near the hills. A large portion of the land in the southwestern part of the valley is contained within the Lankershim and Van Nuys ranch. This property is being sold to settlers in tracts of from 5 to 20 acres. Grain ranches along the bordering hills vary from 80 to 300 acres in size. A 1,500-acre olive grove, the largest in the world, is located near San Fernando. The McClay Rancho Water Company and the Mission Land and Water Company control a large acreage near San Fernando in this section of the valley while individual holdings are from 10 to 40 acres. The Tejunga Water & Power Company has subdivided a large tract of land below Tejunga Canyon and some small tracts have been purchased by settlers. Near Burbank the land holdings range from 20 to 80 acres while on the extreme lower portion of

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the river about Glendale the holdings are smaller and seldom exceed 40 acres. Many vegetable gardens of 5 to 10 acres are within the city limits.

The southwestern portion of the San Fernando Valley, comprising fully one half of the entire area, has been used for grain growing and grazing for many years. In 1912, 11,000 acres of sugar beets were grown by the American Sugar Beet Company without irrigation in this district. Some alfalfa is irrigated near Chatsworth and throughout the northern portion of the valley citrus fruit, olives, alfalfa, and grapes are irrigated; also some garden truck in the Tejunga area. The citrus orchards near Burbank and Glendale are all irrigated; also some of the walnut orchards. Some alfalfa near Burbank is irrigated. A great variety of garden vegetables are irrigated along the river just above the city of Los Angeles. Citrus and deciduous fruits, olives, and grapes are irrigated at La Canada and La Crescenta. Some deciduous fruits are grown in the eastern portion of the main valley but they are not generally irrigated.

A total of 10,010 acres in the main valley, and 800 acres in La Canada Pass is irrigated. Most of the irrigation in the main valley is near Fernando and Burbank. The Chavez-Feliz ditch covers 300 acres of the vegetable district on the west side of Los Angeles River in the city. Land near La Canada, La Crescenta, Glendale, Fernando, and Roscoe are furnished water by small companies. Pumping plants are scattered throughout the northern and eastern portions of the valley and in many cases they are used to supplement water from company systems when the supply is low. The land near Burbank is irrigated exclusively from private pumping plants.

. The city of Los Angeles, in planning for the disposal of water brought from Owens River by the aqueduct, places the duty of water for San Fernando Valley at seven and one half acres per miner's inch flowing continuously, or 5 acres per miner's inch for a season of 250 days, which is equivalent to 2 acre-feet per acre. Near San Fernando the companies now operating estimate that 1 miner's inch is sufficient for from 7 to 8 acres and orchards are giving good results with the use of 1.1 to 1.5 acre-feet per acre annually. Tejunga Water and Power Company allows 1 miner's inch for 5 acres at a rate of 1 cent per 24-hour inch. A miner's inch under the Verdugo Canyon system serves 7 acres. The Monte Vista Water Company delivers 60 miner's inches for twenty-four hours to 20 acres every twenty-three days, making the amount applied .9 acre-feet for a season of six months. The average amount of water used in the vegetable gardens is from 3.5 to 4 acre-feet per acre per year. Some of the walnut orchards near Burbank receive from .5 to .8 acre-feet per acre while others are not irrigated. In this locality alfalfa produces seven crops per season, there being an irrigation for each. The duty of water for alfalfa, based on the discharge of pumping plants claimed by farmers, is from 2.5 to 2.8 acre-feet per acre. Alfalfa is irrigated by being flooded between field borders and by the use of detachable surface pipe. Water

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is usually distributed in the truck gardens by board flumes. For citrus orchards concrete underground pipe systems are used. The conditions for drainage in the San Fernando Valley are good. The sandy character of the soil and the rapid fall in the land are conducive to natural drainage.

The Spanish Pueblo of Los Angeles was granted all of the waters of Los Angeles River. The Supreme Court of California in upholding this right has ruled that all the waters of the river and its tributaries both above and below the ground surface may be used by the city if needed. As this includes the entire drainage basin of San Fernando Valley development of water by private corporations has been somewhat discouraged. The city's pueblo right is strengthened by domestic use being superior to agricultural use. In late years the city has enjoined a number of individuals from operating pumping plants in the valley but it is understood that the right is to be enforced only in case of shortage, which contingency is not likely to arise in the future as the aqueduct will supply more water from Owens River than is needed for domestic use. The rights of the Chavez-Feliz ditch are defined by the court decisions and some water is allowed for use under this ditch. Water from Brown's Canyon is claimed by the San Fernando Water Company. Water from San Fernando Creek is used by the Mission Land and Water Company while that from Pacoima and Little Tejunga creeks is diverted by the McClay Rancho Water Company. Rights on Tejunga River seem well adjusted between the company and the private appropriators. Litigation over the water from Verdugo Canyon has now been settled. The Tejunga Water and Power Company has filed on all of the unused waters of Tejunga River to be used for both power and irrigation and this company controls ten mountain reservoir sites on the river which it is proposed to develop in the future. It is probable that construction of one or more of these will be begun as soon as water from Owens River becomes available for use in Los Angeles and the surrounding country. The use of the water for power will not be adverse to irrigation as it can afterwards be delivered for use on lands below Tejunga Canyon and too high to be covered from the aqueduct reservoirs.

It is probable that reservoir sites might be found on Little Tejunga and Pacoima creeks suitable for storage of the flood waters. The San Fernando Water Company holds a reservoir in Brown's Canyon with an estimated capacity of 2,500 acre-feet but the watershed of this stream is so poor that the reservoir has not been of great value. Two reservoirs, with a combined capacity of 40,000 acre-feet, are to be constructed in connection with the Los Angeles aqueduct northwest of Fernando and another is projected for a site southwest of Chatsworth with capacity of 45,000 acre-feet. A reservoir at this point would be in a position to serve 23,700 acres in the southwestern portion of the valley.[1]

[1]Report of Advisory Engineers on distribution of surplus water from Los Angeles aqueduct.

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The chief source of water for the further development of Fernando Valley will be the Los Angeles aqueduct. The city taking about 60 cubic feet per second by pumps from the river in and it was estimated that about double this amount will be requ for domestic use within a few years. Allowing for this increased there remains 360 cubic feet per second of water to be brought by aqueduct by 1913 for use in irrigating lands adjacent to the The plans being formulated for the disposal of this water will cor its use to districts now adjacent to the city which can be convenie annexed if the population spreads until it covers these lands. If water is used for irrigation at the rate of 1 miner's inch per seven one half acres and at some future time the water is required domestic instead of agricultural uses on these lands there will be r than a sufficient amount for domestic use. The surplus water from aqueduct will be more than is needed for the irrigation of all of land of San Fernando Valley. It is proposed to give the land ow of this valley preference in subscribing for the use of water from aqueduct because its application in San Fernando Valley will advantageous to the city in several respects. It would no doubt req less distributing pipe than for the conveyance of water to distr south and east of the city. The chief advantage, however, is the fa able condition for the recovery of water that returns to Los Ang River from the soil. It is estimated that one fourth of the amo applied to land in San Fernando Valley will reach the narrows at the city as surface or underground water. It is the plan of the to construct and retain ownership of the main distributing pipes f the aqueduct and to charge an annual rental to associations of w users taking the water. The price proposed is reasonable compa with prices for water for citrus orchards south of the Sierra Ma Range. The terminus of the aqueduct north of San Fernando is an elevation of 1,400 feet above sea level. From this point the wa will drop 300 feet to the San Fernando reservoirs, the resulting h being used for the development of power. The reservoirs have elevation that will command 95,000 acres by gravity in the val The extreme northern portion of the valley above these reservoirs be fully irrigated from Tejunga River, Pacoima Creek, and ot local sources.

If the restriction imposed by the city on the pumping of und ground waters in San Fernando Valley is withdrawn it is expec that development will proceed rapidly. The underground water co tions already favorable will be improved by seepage from land supp with aqueduct water.

Water can be pumped for $.005 to $.015 per miner's inch per h throughout the greater portion of the valley. In general the depth ground water becomes less from the north and west to the southw Water stands at 80 feet below the surface in a well 300 feet deep the olive grove above San Fernando. Wells north and east of S Fernando from 80 to 100 feet in depth require the water to be lif

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about 60 feet. Water stands at from 50 to 80 feet in wells drilled from 250 to 300 feet in the vicinity of Van Nuys. Near Burbank the depth to water is usually not over 30 feet and wells are bored from 60 to 100 feet deep. The pumping lift on the Orange Cove tract is 212 feet. It is not expected that the irrigated area near Glendale will increase as this is fast becoming a suburban residence district to the city. Eagle Rock Valley near Glendale formerly contained some irrigated land but this is now being transformed into a suburb. Water must be lifted about 160 feet near La Canada. It is probable that this section will also become a residential district. Near Sunland south of Tejunga River water must be lifted from 60 to 80 feet in wells.

The entire watershed tributary to the San Fernando basin is 310 square miles in area. The most valuable part of the watershed as a water producer is that drained by Tejunga River, Little Tejunga and Pacoima creeks with an area of 190 square miles. The run-off from this area should be sufficient with storage to supply all of the lands in San Fernando Valley that cannot be economically reached by laterals from the aqueduct or from wells.

SAN GABRIEL VALLEY.

San Gabriel Valley, like San Fernando Valley, is almost completely surrounded by hills and mountains. Its only drainage exit is Paso de Bartolo, two miles wide. Besides San Gabriel River, small streams that enter the valley from San Gabriel Mountains, to be lost in the sands but which may be considered tributaries of the main stream, are: San Dimas Creek, Big Dalton, Little Dalton, Sawpit, Santa Anita, Little Santa Anita, Eaton, Los Flores, and Rubio canyons. Arroyo Seco enters the northeastern corner of the basin above Pasadena, but finds an outlet to Los Angeles River through the hills on the west. Millard Canyon joins the arroyo. San Gabriel Valley consists of the débris fans or cones of the river and tributaries. The alluvium has been raised until it is certain, as shown by borings, that the depth to bedrock at places exceeds 1,000 feet. It is evident that there is some barrier to the passage of underground water southward from Pasadena and that this barrier, now buried by the alluvium, is an extension of Raymond Hill and Oak Knoll toward the northeast, although the surface contour shows but little evidence of such extension. A similar condition is found at the eastern extremity of the valley near the head of San Dimas wash where hills intercept the underground waters. The head of this wash is very favorable for securing good wells, although the summer discharge of San Dimas Canyon is very small. The débris cones of the streams are very coarse and porous near the canyons and readily absorb large quantities of water. Boulders, cobbles, and gravel are found in great abundance along the washes. The material becomes gradually finer and grades to sand and silt in the lower courses of the channels. The water of all tributaries of San Gabriel if not taken out for irrigation would be entirely absorbed before reaching the river except during floods. The river itself has considerable discharge throughout the year, although all

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of the water is diverted in the canyon for irrigation during the summer. The lower part of San Gabriel Valley has an abundance of underground water due to all water absorbed above having to go through Bartolo Pass.

Portions of San Gabriel Valley are highly developed, due to their natural surroundings and to their proximity to Los Angeles. The portion of the valley east of the river includes the famous citrus districts of Covina, Azusa, Glendora, and San Dimas. The higher lands in the western section about Pasadena, South Pasadena, Alhambra, San Gabriel, Altadena, Sierra Madra, Monrovia, and Duarte, are as well adapted to citrus culture as the eastern portion of the valley, but, excepting Duarte, are not so advantageously situated for water from streams. The upper portion of the San Gabriel basin has gravelly and sandy loam soils and good drainage, the slopes being from 100 to 200 feet per mile. The lower portion of the valley slopes at the rate of about 50 feet per mile and has soils finer in texture. These low areas are frequently visited with frosts and are not adapted to citrus culture. A variety of crops are raised, including alfalfa, deciduous fruits, English walnuts, strawberries, and garden truck, all of which are irrigated, and barley for hay and grain grown without irrigation. A large part of the Baldwin ranch, including the La Puente grant, is devoted to grain growing. This property borders San Gabriel River and has an area of 3,300 acres. Aside from this ranch holdings are generally small, the usual size of an orange orchard being about 10 acres. Walnut orchards are from 10 to 40 acres.

The San Gabriel Valley has a total of 78,636 acres of agricultural land, of which 36,536 acres are irrigated. Water for the foothill districts on the west side of the river is secured from pipe lines and tunnels in the small mountain canyons and from pumping plants. Several water companies furnish domestic water to Pasadena and surrounding settlements, the service including the irrigation of small tracts of fruit, garden, lawns, and shrubbery. Two submerged dams have been constructed in the channel of Arroyo Seco, which have been effective in raising the water level behind them and thereby reducing the head against which pumping plants must work. The Azusa and the Covina irrigating companies supply about 1,000 acres of citrus orchards near Azusa, Covina, and Glendora on the east side of the river, the water being diverted from San Gabriel Canyon by a dam and tunnel and conveyed to the orchard by cement-lined ditches and underground cement pipe. The Duarte Mutual Company diverts water on the west side of the river for citrus orchards. A small amount of gravity water is secured from San Dimas Canyon by the San Dimas Irrigation Company, but the main supply of this company is from pumping plants in the head of the wash near San Dimas. Water is pumped in the wash below San Dimas Canyon and conveyed to lands near Glendora, Azusa, and Covina. There are in all over 40 water companies. Nearly all of these supply water for agricultural purposes alone and are mutual organizations of the land owners. The systems of the private companies that formerly furnished domestic

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water to Pasadena were purchased by the city in 1912. There are no flowing wells, but pumping plants are found throughout most of the valley. Some of the most productive wells to be found are those in the vicinity of Irwindale, pumped to supplement the gravity supply of the Azusa and Covina Irrigating Company. Single wells in this locality are claimed to deliver upwards of 300 miner's inches. The gravels which they penetrate are supplied by water percolating southward from San Gabriel wash. These gravels are so coarse that they not only give up the water with which they are saturated very readily, but are soon recharged by the flood waters from San Gabriel Canyon. The Irwindale wells are bored to depths of 400 to 500 feet and the water must be lifted from 60 to 100 feet. The depths of wells in San Dimas wash is about the same, but the lift is higher and varies from 150 to 225 feet. There is an abundance of underground water south of El Monte and just above Bartolo Pass, the plane being from 5 to 10 feet below the ground surface. North of El Monte the depth to well water increases to about 90 feet. In the vicinity of San Gabriel and Alhambra the water level stands at from 50 to 100 feet below the surface.

The following companies operate in San Gabriel Valley, nearly all of which are mutual organizations:

San Dimas Irrigation Company.
Artesian Belt Water Company.
Le Verne Irrigating Company.
Frostless Belt Water Company.
New Deal Land and Water Company.
Glendora Mutual Water Company.
Glendora Irrigating Company.
Azusa Irrigating Company.
Azusa Agricultural Water Company.
Citrus Belt Water Company.
Covina Irrigating Company.
Columbia Land and Water Company.
La Puente Coöperative Water Company.
Duarte Mutual Irrigation and Canal Company.
Beardslee Water Ditch Company.
Monrovia Water Company.
Monrovia Acres Water Company.
Walnut Grove Mutual Water Company.
Sierra Madre Water Company.
Baldwin Park Water Company.
West Coast Water Company.
Lincoln Avenue Water Company.
Euclid Avenue Water Company.
Rubio Canyon Land and Water Association.
Los Flores Water Company.
Precipice Canyon Water Company.
Craig Lambert Water Company.

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Garvey Water Company.
Fairlee Water Company.
Pasadena Land and Water Company.
Pasadena Lake Vineyard Water Company.

The duty of water for citrus orchards throughout this belt may stated as about 10 inches in depth annually on the land or as from 7 t acres per miner's inch flowing continuously. In the lower part of t valley walnut trees are sometimes set with an unusually wide spaci and alfalfa grown between the rows. For this land it is usual to app from 2 to 3 acre-feet of water per acre annually. Walnuts alone requ less water than citrus fruits. Agricultural practice is as good as can found in any irrigated district in the West, the culture being ve intense, especially in the orchards. Every precaution is taken to c serve the moisture applied. Several areas of moist land on the Potr Grande grant have been tile-drained with good results. The water p viously stood within 5 feet of the surface. As more wells are drill to supply the unirrigated lands of the Baldwin ranch it is probable th the ground water will be sufficiently reduced to dry some of the land th is now moist along the southern boundary of the basin. Alkali is n present in these localities to any great extent.

The rights of most of the companies diverting water from the strea have been fixed by court decrees. The San Gabriel Power Compa utilizes a portion of the waters in San Gabriel Canyon for the develo ment of electric power. The company has constructed a submerg dam across the canyon, which is one of the most effective dams of th type and which enables practically all of the normal flow, both surfa and underground, to be conducted through the power house. The co veyance of the water in pipes for power results in a saving. The salva has been determined and has been purchased by the Covina Irrigati Company, by which it is used.

Considerable of the land now being dry-farmed in San Gabriel Vall can be irrigated with underground water, but it is not probable that th supply will be sufficient for all of the dry land and it is doubtful if the will be any material increase from a more economical use of water. T Los Angeles aqueduct engineers report that water could be convey from the aqueduct at a point north of San Fernando, through Canada Pass to lands at Pasadena, South Pasadena, and Alhambra, a estimate that the city can afford to furnish water for the irrigation 13,920 acres after first providing for San Fernando and Cahuen valleys. It would also be possible to extend the service of the aqued to an area of 38,250 acres west of the river and 40,000 acres east of t river in San Gabriel Valley, provided the water is not asked for by t land owners of San Fernando or Cahuenga valleys. Water, if receiv from the aqueduct, will be at the rate of 1 miner's inch for seven a one half acres. The discharge of the stream is so erratic from season season that storage reservoirs, to be serviceable, should have sufficie

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capacity to hold back enough water from years of copious rainfall for use in dry years. A high cost for storage should be justified by the value of the water for citrus orchards. One of the most serious problems in the maintenance of reservoirs on such streams as the San Gabriel is to prevent the rapid filling up of the basin by the débris carried by the streams. Reservoirs in some of the main canyons would have to pay for themselves in a comparatively short period of years, as their capacity and usefulness would be reduced. So long as dams are not constructed for the storage of flood waters much could be accomplished in replenishing the underground waters of San Gabriel Valley by the spreading of the flood waters over the gravels below San Gabriel Canyon. This kind of storage has been effective on other streams in southern California where the conditions are no more favorable than those on the San Gabriel.

The San Gabriel has a mountain watershed of 222 square miles, over which the annual precipitation varies from 15 to 40 inches. The winter snows are held on the higher peaks well into the summer. The gagings[1] of the river above Azusa since 1896 show a maximum discharge of 11,000 cubic feet per second occurring in March, 1905. The minimum discharge is 3 cubic feet per second in July; also September of 1899, and September, 1900. The greatest total annual discharge is 351,000 acre-feet, the amount for 1906-7, and the lowest 10,000 acre-feet, the amount for 1898-99. The mean annual discharge is 104,500 acre-feet. Without storage the entire discharge of San Gabriel River and of the other small streams entering the valley is not sufficient in the driest years for the irrigation of all of the agricultural land, but with storage capacity sufficient to take care of all of the flood waters in ordinary years and with further development of underground waters it is possible that all of the land can be irrigated.

SAN JOSE CREEK VALLEY.

The territory included under this heading is the valley of San José Creek, reaching from Puente to a point about 2 miles below Spadra. The valley is from 1 to 3 miles in width only and lies between Puente and San José hills, the latter range separating it from Covina Valley on the north. San José Valley contains a total of 10,350 acres, of which 3,401 acres were irrigated in 1909. The greater portion of the land lies within Rancho La Puente, but the lower valley lands which are irrigated have been cut up into holdings of from 5 to 40 acres. The higher lands bordering the hills on both sides of the valley are used for grain and hay and are dry farmed in larger tracts. Several small ditches take all of the surface flow of San José Creek during the irrigating season. In recent years many pumping plants have been installed in the bottom lands close to the creek. Oranges, lemons, deciduous fruits, strawberries, and alfalfa are the principal crops irrigated, while many of the English walnuts also receive water. Alfalfa and

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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deciduous fruits are not grown in large quantities, but the valley ha developed very rapidly during the past few years by the increase i citrus and walnut orchards and berry patches.

The ditches along San José Creek have rights based on the riparia land irrigated and on appropriation and use. One case of litigatio hinged principally on whether underground water was the subterranea flow of the creek or percolating water saturating the valley. In th recent suit entitled *Hudson* vs. *Daily*, the court enjoined the defenda from driving a tunnel where it would draw water already appropriate directly from the creek itself.

San José Creek has no mountain watershed and the local drainag from San José and Puente hills is of little consequence. A few floo water channels reach back into the hills for 3 or 4 miles, but there i scarcely any surface flow in any of these when water is needed for irr gation. Further development by the extension of the irrigated are must come entirely from sinking more wells or from a more economica use of water. At the present time a goodly number of wells are bein drilled in the lower part of the valley, from Walnut to Puente, and it i difficult to estimate the ultimate acreage that can be irrigated without a overdraft on the underground supply. There has been some reductio in the underground level during the past few years, but as yet the pump ing lifts are not comparatively high. It is probable that at least tw thirds of the agricultural land will eventually be brought under irriga tion. Owing to the proximity of the hills inclosing San José Valley th precipitation is greater than in the more open and larger valleys on bot the east and west. The section about Walnut, in spite of its compara tively low elevation with reference to Pomona, Covina, and other neigh boring fruit districts, is favorable for the growing of oranges, an damage which would otherwise result from frosts in this lower area i prevented by the unusual air movement through the narrow valley Berry growing and truck gardening will no doubt continue to be one o the principal industries.

LOS ANGELES COASTAL PLAIN.

The coastal plain south of Los Angeles and east of Orange County 242,500 acres in area and is one of the largest bodies of agricultural lan in southern California. The plain is limited on the north by Sant Monica Mountains and Puente hills. On the west is the Pacific Ocea and on the south San Pedro Bay. The part from Hollywood to Sant Monica is known as Cahuenga Valley. The plain has a gentle slop from elevations of 200 to 300 feet along its northern boundary to se level. The land probably originated in part from the alluvial deposi of Los Angeles and San Gabriel rivers and in part by the wash of th sea. There is no exact demarcation between the lands of these tw rivers and those of Santa Ana River, farther to the east. A conspicuou break in the slope of the plain itself is a ridge or line of knobs runnin southeast from Cahuenga Valley to Alamitos Bay at the mouth of Sa Gabriel River on the southern coast, the highest point of which is L

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Cerritos, just back of Long Beach. This ridge is an important factor in the action of underground water by holding a high level on the upper side.

The soils throughout this area are generally fine in texture. A large area on Ballona Creek has dark brown loamy soil. Some clay is found in the vicinity of Inglewood, but the most of the soil is sandy and silt loam, the latter occurring along the river channels. The bench lands near Whittier consist of an open surface soil with good drainage underlaid with a more compact subsoil. Some adobe occurs in the lowest portions of the plain and limited areas of peat border Alamitos Bay, Wilmington Lagoon, and several sloughs. Lands containing from 1 to over 3 per cent of alkali are near Wilmington Lagoon, northeast of Inglewood, south of Gardena, near Nigger Slough, north of Dominguez hills at the mouth of Ballona Creek, and in a few other isolated spots.[1] Some of the land along Los Angeles and San Gabriel rivers has from .6 to .4 per cent, while throughout the remainder the alkali content is less than .4 per cent. Much of the low land between the two rivers is moist and has been used principally for pasture. Sugar beets are grown on portions where there is too much salt for other crops.

In the vicinity of Whittier the land has a slope of about 50 feet per mile, but the lower portions of the plain are very flat. This entire area was originally in Spanish grants, which, after passing into the hands of American owners, were first operated as large ranches, but in later years some have been colonized. As a result of this the land holdings are either very large or very small. Near Inglewood and Gardena tracts are usually from one half to 5 acres. Throughout the coastal plain the subdivided land holdings seldom exceed 40 acres and the majority are from 5 to 10 acres.

Citrus and deciduous fruits, garden truck, strawberries, and alfalfa are always irrigated as are most of the walnuts. The irrigation of sugar beets usually consists of a single irrigation of the land before the seed is planted. Beans irrigated in 1911 under the Rodeo Land and Water Company system gave an increased yield of about one third. Citrus fruits are confined nearly altogether to the bench lands bordering Puente hills, near Whittier. Just below these lands is a strip of country reaching as far south as Downey, devoted largely to the culture of the English walnut. Throughout the rest of the plain the crops are diversified, barley, corn, melons, and beans being grown without irrigation in addition to the irrigated crops previously mentioned. Lima beans occupy a large area in Cahuenga Valley and English walnuts and alfalfa are grown along Ballona Creek. Some citrus orchards are located near Hollywood. The territory immediately adjoining the Los Angeles city limits on the east and south and including the settlements of Newmark, Gardena, Moneta, and Inglewood, is devoted largely to garden truck and berries, while sugar beets are best adapted to the low-lying lands near the southern coast. Alfalfa is grown throughout the central portion of the plain and about Artesia and Norwalk. Some orange groves are

[1]U. S. Dept. Agr., Bureau of Soils, Soil Survey of Los Angeles Area, Cal.

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found in the Whittier hills. Whittier is one of the important walnut sections in the State and has an association with 180 members representing about 3,000 acres in groves. The value of the walnut crop of this district is estimated at about one million dollars annually. Some walnut orchards are, however, being replaced with Valencia oranges.

A total of 117,507 acres is irrigated on the coastal plain. Except for the territory about Whittier and Downey, the greater portion of the land is supplied from pumping plants and artesian wells. The Whittier district is supplied by a number of old ditches taking water from San Gabriel River, near Bartolo Pass. The East Whittier Irrigation Company ditch of later construction supplies 5,600 acres, principally at East Whittier. Twenty small water companies are operating on the coastal plain. Most of these secure water by pumping from wells.

Alfalfa is irrigated five times, and 1 miner's inch for 250 days serves about 3 acres. For fruits and berries 1 miner's inch is sufficient for about 7½ acres. The old ditches on the San Gabriel are owned and operated mutually by the landowners, while some of the smaller water companies are private corporations selling water.

The water rights of the old San Gabriel River ditches are based on appropriation and use; also in most cases on the riparian character of the land served. The summer flow of Los Angeles River below the narrows is very small as all of the surface water and nearly all of the underground water is diverted by the city above the narrows. There is a small surface flow in the lower course of the river, but this is very unreliable and the American Colony ditches are usually dry when water is most needed, so that wells are now being bored to insure a more certain supply for these lands. Since the greater part of the land on the coastal plain is supplied with water from wells there has been very little litigation over water rights outside of the Whittier district. A suit entitled *Arroyo Ditch and Water Company* vs. *San Antonio Irrigating Company* over the diversion of water in San Gabriel River, begun in 1886, was compromised.

Bartolo Pass is extremely favorable for securing both surface water and underground water, as all the drainage into San Gabriel Valley must pass through this gap. The coastal plain has comparatively little local watershed. The run-off from Puente hills occurs immediately after rains and is of little consequence. That from Santa Monica Mountains adds somewhat to the underground waters of Cahuenga Valley and to Ballona Creek. The rainfall over the coastal plain varies from 12 to 16 inches, being least at the coast and greatest near the hills. The record at Los Angeles for a period of thirty-four years is 15.60 inches. The underground water must be looked upon as the most available source of supply for further development of this region. Cahuenga Valley is to be given opportunity to subscribe for water from the Los Angeles aqueduct for 30,000 acres and there is a possibility of 21,000 acres near Inglewood and 29,000 acres near Redondo receiving water from the

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aqueduct in case it is not all taken for higher lands.[1] Water supplied from the aqueduct will be at the rate of 1 miner's inch for 7½ acres, or with storage in Franklin Canyon of the Santa Monica Mountains, 1 miner's inch for 5 acres for 250 days. It is probable that the underground waters are sufficient for the irrigation of a portion of the land not now being watered. The largest artesian basin in southern California lies within this plain and good wells can be secured in almost any locality. The artesian area was reduced somewhat in 1905 and 1906 following years of low rainfall, but since that time there has been a slight rise in the level of the underground water. The source of the underground water is the precipitation over the drainage basins of Los Angeles and San Gabriel rivers and it is probable that the winter floods in these streams contribute most to the underground supply. The water which is absorbed by the sands and loose sediment along the streams percolates toward the sea. It is arrested somewhat by the ridge running northwest from Alamitos Bay and a level is maintained on the northeast side of this ridge, which is considerably higher than the level on the side towards the sea. This brings the ground water to the surface of the lowest lands bordering the upper side of the ridge and accounts for the large area of moist soil near Los Cerritos and for numerous marshes in this section. As the artesian area enlarges and contracts with wet and dry periods its upper boundary shifts north and south. At one time the upper edge of the area was as far north as the Laguna between Los Angeles and Whittier, but at the present time it extends no farther north than Norwalk and Downey. The area includes most of the country about Compton, Clearwater, and Artesia and extends towards the southeast across the Orange County line, where there is an area about as great as that in Los Angeles County. In general, flowing wells are secured by boring into strata from 200 to 700 feet in depth. Near Artesia wells 200 feet deep do not as a rule flow all summer, but wells 600 feet deep continue to flow throughout the dry season. A new well 700 feet deep one mile east of Norwalk gives a discharge of 20 miner's inches, a large portion of the water being from a stratum about 400 feet in depth. The Compton wells, from 300 to 700 feet deep, flow following years of good precipitation, but they must be pumped during dry periods. The water stood from 6 to 8 feet below the surface in 1912. Wells 150 feet deep in this locality flowed 25 years ago. At Fruitland, just south of Los Angeles, at an elevation of 200 feet, the water stands at a depth of 60 feet from the surface in wells bored to a depth of 300 feet. The artesian area at one time reached this locality, but its northern limit is now about 8 miles to the south. Near Downey, in a new well 171 feet deep, the water stands at 7 feet below the surface and is pumped down an additional 18 feet when discharging 100 miner's inches. Wells 700 feet deep in the same locality are flowing. The well of the Santa Gertruda Water Company, near Los Nietos, is 700 feet deep and requires a lift of 30 feet when pumping 200 to 300 miner's inches. In the area

[1]Report of Advisatory Engineers on distribution of water from Los Angeles Aqueduct.

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directly east of Los Angeles and north of the Laguna water must l lifted from 10 to 50 feet by pumps, the wells being 500 or 600 feet depth. About Gardena and Inglewood wells are bored from 150 to 6 feet in depth. The water usually rises to within from 50 to 65 feet the surface. The depth of wells in Cahuenga Valley is as follows: Ne Santa Monica 75 to 150 feet, near Sawtelle 75 to 200 feet, near Ballo 100 to 300 feet, and near Hollywood 150 to 300 feet. Wells for irrig tion usually deliver from 50 to 100 miner's inches of water each. A we 912 feet deep on the American Colony lands north of Long Bea delivers 75 miner's inches when pumped. Water stands at 5 feet belo the surface. The fluctuations in the ground water level seldom exce 20 feet in one year. In most localities the water level is higher in wint than in summer, a noticeable rise beginning in August.

The land about Whittier and Downey is already highly develope although extensions of the citrus orchard district are encroaching on t foothills. The principal reason why development has not been mo rapid in some localities is that all the land being in Spanish grants h been acquired in large tracts by companies and held at high prices.

The central portion of the plain is not so desirable for residences the terraces bordering the Santa Monica Range and has been mo strictly on an agricultural basis. A large area of moist land ne Long Beach needs drainage to make it highly productive and prof able. Some of this land is now producing sugar beets but with drai age more valuable crops could be grown. Where there is much alk drainage alone may not be sufficient to reclaim the land, but the leac ing of the soil resulting from irrigation may accomplish the desire result. The Bixby Land Company has tile drained 300 acres wi the result that the salt content of the land is much reduced. Portio of the coastal plain are adapted to alfalfa and dairying and there is ready market for dairy products.

Summary for Los Angeles and San Gabriel River Lands.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
San Fernando Valley	110,500	10,010	105,000	Los Angeles aqueduct, storage Tejunga River and undergrou waters.
San Gabriel Valley	78,636	36,536	70,000	Los Angeles aqueduct, storage San Gabriel River and und ground waters.
San José Creek Valley	10,350	3,401	6,500	Underground waters.
Los Angeles coastal plain	242,500	117,507	200,000	Los Angeles aqueduct and und ground waters.
Totals	441,986	167,454	381,500	

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SANTA ANA RIVER LANDS.

This division is different from that including Los Angeles and San Gabriel rivers by having its water supply entirely within its boundaries. A miner's inch of water serves 7 to 8 acres of citrus orchard, 10 or more acres of deciduous orchard, and 3 acres of alfalfa in districts at the base of the San Gabriel Range, and 5 acres of citrus orchard at Redlands and Riverside. That production has not been lessened by lack of water is shown by the large shipments of citrus fruit and by the high market value of alfalfa ranches.

Values are not so much affected by city suburban influences as in the division embracing Los Angeles and San Gabriel rivers, although the Santa Ana division includes choice residential districts. Orchards must produce fair interest on the investment and values are on this basis.

Part of the flood waters of Santa Ana River are already stored in the mountains, but there is opportunity for further improvements of this kind. Much more pumping will also be done from wells along the Santa Ana. The principal thing which remains undetermined is the extent to which pumping in the upper basins will affect the water supply in Orange County. Water rights are based on appropriation and use and filings are regarded as superficial. The litigation on the Santa Ana, of which there has been much, has developed some of the fundamental principles of water rights in California, especially with reference to underground waters.

POMONA VALLEY AND CUCAMONGA PLAINS.

The territory included under this heading is at the southern base of the Sierra Madre Range from San Dimas to Lytle creeks and is limited in area. It is bounded on the south by Chino hills, Jurupa Mountains, and the Santa Ana River. The region embraces several débris fans spreading from small canyons in the Sierra Madre Mountains and which combine to form a gently sloping plain toward the south from this range. The drainage is to Santa Ana River, but the surface flow of the stream does not ever reach the river and the territory is considered apart from the Santa Ana River drainage in the San Bernardino basin. In former years the flood waters of San Antonio Creek sometimes crossed the valley and reached Chino Creek without sinking into the sands and were then carried by this stream to the Santa Ana. The waters of Chino Creek are brought to the surface by the hills which intervene to prevent further passage of underground waters percolating southward from San Antonio Canyon.

This section includes Pomona, Lordsburg, Claremont, Ontario, Upland, Cucamonga, Etiwanda, and Chino. The chief industry about these settlements, except the last mentioned, is the growing and shipping of citrus fruits. The alluvial lands, like those of the San Gabriel Valley, are very coarse in the upper areas below the mountain canyons, the material becoming gradually finer as the low areas by the southern

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hills are approached. The washes of the streams branch out into numerous gravelly channels below the canyons where some land is so rocky that it is doubtful if it will ever be reclaimed for agricultural purposes even though water should be available for irrigation. Farther away from the foothills the soil is gravelly but is very productive when the boulders and cobbles are removed and water applied. Sandy loams predominate farther down the slope and black adobe is found in the lowest areas. Before the country was developed these adobe lands were very moist and the long continued growth and decay of vegetation blackened the soil. A few mesas or bench lands bordering the foothills differ in character from the gravelly lands about the mountain canyons. These bench lands are reddish in color as contrasted with the decided gray of the wash. Conspicuous among them are the heights about Le Verne and Lordsburg, Indian Hill just above Claremont, and Red Hill northwest of Cucamonga. Alkali is not in evidence except in the low moist lands bordering Chino Creek and Santa Ana River. Several hundred acres south of Chino have been drained by the American Beet Sugar Company for the growing of sugar beets. Drainage has been effective in removing much of the salt. The principal purpose of drainage, however, was to rid the land of its moisture in order that early planting of beets might be practiced. The soil, too salty for ordinary crops, would produce sugar beets without drainage. The slope of the land is very steep near the base of the mountains, averaging 200 feet per mile. The lower part of the valley has a fall of only about 50 feet per mile. Practically all of the upper lands are planted to citrus fruits, the orchards being in almost solid areas wherever water can be secured for their irrigation. In the southern and southeastern portion of the division, where the soil is too tight and the frost too severe for the growing of citrus fruits, the crops consist principally of alfalfa, deciduous fruits, English walnuts, sugar beets, berries, and garden truck. The eastern portion of this territory is the least developed, there being little or no water for irrigation. The Italian and other vineyards occupy several thousand acres of sandy soil from Cucamonga and Etiwanda southeast to Jurupa Mountains. Portions of this section which are without water for irrigation, not planted to grapes, are utilized for grain. Orchards are usually about 10 acres and alfalfa ranches from 20 to 80 acres. A large portion of the lower plain is occupied by the Chino grant on which there is 19,000 acres of tillable land. This grant, after passing into the hands of American owners, was under mortgage for a number of years, preventing sale of the land and causing settlement to be slow compared to other places in southern California with equal opportunities. In 1906 the indebtedness against this property was cleared and since that time development which had previously been begun around Chino has extended rapidly toward the south and east until at the present three fourths of the land is occupied.

The chief source of water for irrigation, especially at Pomona and Chino, is the underground supply. All of the summer discharge from

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the mountain canyons was appropriated and used years ago. After first satisfying an old right, the summer discharge of San Antonio Creek is divided about equally between Pomona and Ontario up to a total 624 miner's inches, in accordance with a court decree. The waters of Cucamonga Canyon are diverted and used by the Cucamonga Water Company and those of Etiwanda and Day canyons by the Etiwanda Water Company. Besides the surface water the subterranean flow of all these canyons is drawn upon by means of tunnels which have been driven into the gravels. The greater portion of the land about Ontario and Upland is under the system of the San Antonio Water Company, which serves approximately 5,000 acres. The canyon water, however, has been supplemented by a goodly supply from pumping plants. The Canyon Water Company uses the greater part of Pomona's share of canyon water, the Irrigation Company of Pomona and Del Monte Irrigating Company depending on water from wells. The following companies supply water to lands in this area:

At Pomona, Claremont, and Lordsburg:

Canyon Water Company, of Pomona.
Irrigation Company of Pomona.
Del Monte Irrigation Company.
Palomares Irrigation Company.
Kingsley Tract Water Company.
Currier Tract Water Company.
Orange Grove Tract Water Company.
Packard Water Company.
Mills Tract Water Company.
Old Baldy Water Company.
Mesa Land and Water Company.
La Verne Land and Water Company.
Live Oak Water Company.
Citrus Water Company.
Illinois Land and Water Company.
Richards Irrigation Company.
Indian Hill Water Company.
Claremont Coöperative Water Company.
Pomona Ranch Water Company.
Harrison Avenue Water Company.
Monte Vista Water Company.
Monte Vista Irrigation Company.
Mont Antonio Water Company.

At Ontario and Upland:

San Antonio Water Company.
Mountain View Water Company.
Ontario Water Company.
Canyon Ridge Water Company.
Upland Water Company.
Ranchers Mutual Water Company.

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At Cucamonga:

Cucamonga Water Company.
Old Settlers Water Company.
Hermosa Water Company.
Iamosa Water Company.
Sunset Water Company.

At Etiwanda:

Etiwanda Water Company.
Rochester Water Company.

At Chino:

Chino Water Company.
Southern California Colonization Company.

Most of the foregoing secure water from pumping plants, and ab
400 pumping plants owned by individuals in addition to those of
water companies are operating. Water is conveyed by undergrou
concrete pipe. The amount used in orchards varies, but averages ab
.8 acre-foot per acre for citrus trees and less for deciduous trees
miner's inch flowing continuously through the irrigating season be
sufficient for 8 acres of citrus orchard. The alfalfa growers on Ch
ranch depend entirely on pumping plants and wells for water.
distributing systems for alfalfa are of underground concrete pipe wh
the method of applying water to the land is by detachable galvani
iron surface pipe. Ordinarily 6 crops of alfalfa are cut, the f
as a rule being produced without irrigation by the moisture retai
in the soil from the spring rains. Measurements of the amount
water used in irrigating alfalfa made in 1905 and 1908 show an ap
cation of 2.4 acre-feet per acre. The mean annual rainfall at Cla
mont for a period of 18 years is 16.95 inches. This rainfall, wh
high for an arid or semi-arid country, is poorly distributed, the grea
part falling in the late winter and early spring. Canyon water
a capitalized value of $1,500 to $2,500 per miner's inch while pum
water is valued at $1,000 per miner's inch. Acre water rights in mut
companies pumping water are worth about $125 while those hav
some of the best established rights to canyon water are worth ab
$300 each.

The rights of most of the appropriators of canyon water have b
determined through litigation although recently a suit was filed wh
involves both the rights to use surface and underground waters fr
San Antonio Canyon. This district has been unusually free fr
litigation over underground waters in the past, considering that th
are so many pumping plants and wells.

It is remarkable that about 20,000 acres are irrigated with the surf
and underground waters from a mountain watershed of only 40 squ
miles. The drainage basins of the streams in this division lies wit
the Angeles forest reserve, San Gabriel Mountains culminating
Mount San Antonio with an elevation of 12,000 feet above sea le

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Snow remains on the higher peaks throughout the late winter and spring, the last of it sometimes not disappearing until midsummer. The canyons are so precipitous that no sites of large capacity for storage reservoirs are to be found for the impounding of flood waters. One small dam has been constructed across Evy Canyon, a branch of San Antonio Canyon, by North Palomares Irrigation Company. Many small concrete reservoirs are in use throughout the valley in connection with pumping plants. These reservoirs are entirely artificial and merely act as regulators in the distribution of water. Brown's Flat, located in the San Gabriel Mountains west of San Antonio Canyon, has been investigated as a storage site but was not given further consideration on account of the high cost.

Effective work has been done in the spreading of storm waters below the mouth of San Antonio Canyon over the coarse gravels where they are absorbed and stored in the underground basins to be drawn on later by the pumps taking water from wells. In the absence of suitable storage sites this is the best means for conserving flood waters resulting from the melting of the snow in the spring at a time too early for direct use on the orchards. The maximum discharge of San Antonio Creek is estimated at 100,000 miner's inches or 2,000 second feet. Floods of this size do not occur every year. The average summer discharge for a 22-year period as shown by the measurements of water companies is as follows: July 820 miner's inches, August 738 miner's inches, and September 557 miner's inches. The other streams entering the valley are much smaller.

The underground waters of the citrus districts have been drawn on so heavily by pumping plants that is doubtful if new wells can be made that will not affect the supply from existing wells. On Chino ranch the water level has not been seriously affected by pumping and it is probable that many more wells can be made in this section without serious damage. Water which is absorbed along the base of the foothills above Upland, Cucamonga, and Etiwanda percolates in a general southerly direction. Water entering the gravels below San Antonio Canyon is in large part forced to move to the southwest by what is evidently an extension of San José hills now buried by alluvium. Wells drilled in the cienegas at Claremont and Pomona flow following periods of good rainfall but the water must be lifted in them from 50 to 100 feet during dry periods. Below these cienegas are wells in which water must be lifted from 100 to 400 feet. A vast water plane with slope toward the south much less than that of the surface appears to be south of Ontario. The pumping lift is about 100 feet at the northern border of Chino ranch. An artesian area which varies in size with wet and dry periods borders Chino Creek. It now occupies about 20 square miles. Many new pumping plants have been installed on wells in the eastern part of Chino ranch within the past few years and some single wells are producing 200 miner's inches. Wells near the foothills as a rule do not produce over 50 miner's inches.

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It is probable that all of the alfalfa district can be irrigated from wells but it is doubtful if there can be any material increase in the citrus districts without an overdraft on the underground supply for these upper lands. Water is already used in these districts with as much economy as can reasonably be expected and it is doubtful if there will be any increase from a more economical use. Pomona Valley and Cucamonga Plains contain 131,448 acres of agricultural land, of which 44,823 acres are irrigated. The total mountain watershed contributing to this territory is 56.9 square miles, over which the precipitation is estimated at 20 to 40 inches annually.

All of the normal flow from San Antonio Canyon is used for the development of electric power before being used for irrigation. The plants of the Pacific Light and Power Company and the Ontario Power Company are located in the canyon. The water from these is returned to the creek above the diversion of the Pomona and Ontario water companies. A portion of Ontario's share is again used in the plant of the Ontario and San Antonio Heights Power Company before it is used for irrigation. The use of water for power is not in conflict with its use for other purposes.

SAN BERNARDINO VALLEY AND RIVERSIDE.

This area contains more irrigated land than any other within the coastal drainage of southern California. Although it lies in two counties, it is considered as one area on account of the common water supply. The supply is Santa Ana River and tributaries, in the San Bernardino Basin, above Colton. The principal tributaries are Lytle and Mill creeks, but Cajon Creek, Devil's and Waterman canyons, Twin, City, and Plunge creeks also discharge into the basin. Warm Creek rises from springs in the cienegas of the basin and flows into Santa Ana River. The Santa Ana has no other important tributaries until Rincon is reached, where Temescal wash and Chino Creek enter the river.

The agricultural lands may be divided into four main divisions. The country north of Jurupa Mountains and west of Lytle Creek, including Rialto, Bloomington, and Colton, contains 48,576 acres, of which 14,250 acres are irrigated. The central portion of the basin, between Lytle Creek and Santa Ana River, including San Bernardino and Highlands, contains 37,817 acres of good land, of which 13,862 acres are irrigated. The Redlands district, lying south of the Santa Ana River, has 21,830 acres of agricultural land, of which 16,080 acres are irrigated. Riverside Valley and Mesa contain 92,300 acres, and 35,800 acres are irrigated. The totals are: Agricultural land 200,523 acres, and irrigated land 79,992 acres.

In general, soils are sandy loams of different grades. The mesa soils of Riverside and Redlands are red and rather heavy, but they contain some sand. Adobe is found in some of the low areas in the San Bernardino Basin and along the river in the vicinity of Arlington. The washes of the Santa Ana River, Lytle and Cajon creeks occupy large areas and it is doubtful if much of this land will ever be

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reclaimed. Some gravelly soil is found along the base of the San Bernardino Mountains and north of Rialto. Soils near Wineville are very sandy. Alkali does not appear in quantities that would be damaging to plant life.

Farms are small where the land has been subdivided, the common size of an orchard being 10 acres. Alfalfa ranches contain from 80 to 160 acres. This area includes, however, several large properties, such as the Arlington Heights groves, under company ownership, 1,500 acres in extent, and several others of several hundred acres. A number of large tracts, usually Spanish grants, which have been acquired by land companies, are being subdivided and colonized. It is customary for the land and water companies to develop water for irrigation, organize subsidiary mutual water companies, and sell the land in small tracts, together with water rights in the mutual companies, to settlers. Tracts of this kind are in West Riverside, and at Fontana, near Rialto.

The value of a right to pumped water is $1,000 to $1,500 per miner's inch, and of gravity water, under company systems, with well-established rights, $2,000 to $3,000 per miner's inch.

Practically all of the upper lands of this area are devoted to citrus fruits. The mesa and higher valley lands have comparatively little frost and soils are medium as regards texture, being neither light nor extremely heavy. Riverside, Highgrove, Arlington, Redlands, Highlands, and Rialto are among the most important citrus districts of southern California.

Highlands and Rialto grow lemons, as well as oranges. Colton, Bloomington, and West Riverside districts are also adapted to citrus fruits. Olives have given excellent results near Bloomington. Alfalfa is grown in the basin below San Bernardino, Highlands, and in Riverside Valley. The section about Wineville is in vineyard. Some deciduous fruit orchards are scattered throughout the territory, where the land is not adapted to citrus culture. Large areas of grain occupy the slopes of the surrounding hills and some of the valley land about San Bernardino and north of Jurupa Mountains where water for irrigation has not yet been provided.

All of the normal surface waters of the streams entering San Bernardino Valley are diverted directly by water companies. Most of the streams discharge throughout the summer. Water absorbed by the gravels below the stream canyons has been collected in the bottom of the basin and a high level of underground water is maintained by Bunker Hill and its extensions, now buried by alluvium. An artesian area, which was originally about 32 square miles, is located in the basin. This section is one of the most valuable for producing underground water thus far found in southern California. Heavy drafts have been made on the underground waters for the past twenty years, and during the dry period ending about 1904 there was a decline in the water level, measuring from 10 to 30 feet in the various wells. Years of better rainfall followed this period, and for a time after 1906 the level was maintained. The draft on the supply, however, increased with new

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wells, the most of which were both larger in diameter and deeper than the older wells, and within the last two or three years there has been an additional slight decline in many wells. The artesian area occupied about 13 square miles in 1904.[1] Some of the new wells are from 800 to 1,000 feet in depth, and some along Lytle Creek and near San Bernardino are claimed to produce between 100 and 200 miner's inches. Many wells outside of the artesian area are pumped, as are some of them that flow slightly. The springs and flowing and pumped wells of the San Bernardino Basin have furnished a large portion of the water for irrigation for the Riverside citrus district during the dry season when water is most needed. Many pumps are also operating on wells in the Riverside Valley. The draft on the underground water in this locality is in general a later development than that in the upper basin. All of the surface waters of the Santa Ana are first taken out at the mountain canyon for use at Redlands and Highlands. The subterranean flow is brought to the surface near Colton and water is here diverted by the Riverside canals. They are again brought to the surface above the Riverside Narrows and the water level is at or near the surface at many points in the lower Riverside Valley. All unused waters of the upper basins must finally enter the canyon below Rincon.

Nearly all water companies securing water from Santa Ana River are mutual organizations. The Bear Valley Mutual Water Company takes water from Santa Ana Canyon to be furnished several mutual companies of the land owners in the various districts of Redlands and Highlands. Among those supplied are:

Crafton Water Company,
Redlands Water Company,
Redlands Heights Water Company,
East Redlands Water Company,
West Redlands Water Company,
Mentone Irrigation Company,
Lugonia Water Company,
Gladysta Mutual Water Company,
Barton Pipe Line and Water Company,
Bear Valley Extension Water and Pipe Line Company,

with lands on the south side of the river; and

North Fork Water Company,
West Highlands Water Company,
Cram-Van Leuvan Water Company,
Green Spot Pipe Line Company,

with lands on the north side of the river.

Formerly these mutual companies purchased water from the Bear Valley Irrigation Company, a corporation which failed financially and went into the hands of a receiver. Its property was acquired by the Bear Valley Mutual Water Company, organized by the water users.

[1] U. S. Geol. Survey, Water Supply and Irrig. Paper No. 142.

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Other Redlands water companies are:

Mill Creek or Old Town Water Users,
East Barton Water Company,
Jewel Water Company,
Gladysta Well and Water Company,
South Mountain Water Company.

Some of the Redlands companies are interrelated by one company owning stock in another and by exchanges of water and rights. For example, the Crafton Water Company exchanges water from the Santa Ana with the Old Town Water Users, for water from Mill Creek.

Companies with lands near San Bernardino are:

Del Rosa Water Company,
West Twin Creek Water Company,
City Creek Water Company,
McKenzie Ditch Company,
Stout Ditch Company,
Rabel Dam Ditch,
Hawes Ditch.

The Del Rosa Company takes water from East Twin Creek and the McKenzie and Stout ditches from Warm Creek.

The following companies receive water from wells and pumping plants in the vicinity of San Bernardino and Colton:

Rancheria Water Company,
Terrace Water Company,
Rosedale Water Company,
North Colton Water Company,
Linda Vista Water Company,
Vista Grande Water Company,
Jumal Water Company,
Merryfield Water Company.

Lands at Rialto and Fontana are supplied by the Lytle Creek Water and Improvement Company, Fontana Water Company, and Mt. Vernon Water Company, with water from Lytle Creek and from pumping plants. Lands near Bloomington are supplied by the Citizens Land and Water Company.

The Riverside Water Company supplies 8,658 acres of Riverside Valley lands. It is mutual in some respects. Water is secured from Santa Ana River, Warm Creek, and flowing wells near Colton, with a supplemental supply during the dry season from pumping plants in the river. The Gage Canal Company and its subsidiary company, the East Riverside Water Company, are mutual companies, serving the upper mesa or citrus lands, including East Riverside and Arlington Heights. Water for this canal is received from Santa Ana River and flowing and pumped wells above Colton. The Riverside-Highlands Water Company is strictly a mutual organization, serving the citrus orchards of the terrace south of Colton. Water is secured from flowing wells in the Colton basin and from pumping plants along Lytle Creek, it being lifted

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to the mesa by large pumping engines. The Jurupa Ditch Company secures water from the Santa Ana River, and the Alvitrez Ditch Company from Spring Brook. The Rivino Water Company secures water from pumping plants.

The following mutual water companies, some of which are related as regards stock ownership, are entitled to water from the river, or have wells and pumping plants, but have water carried by the canal of the North Riverside and Jurupa Canal Company:

Meeks and Daley Water Company,
West Riverside 350 Inch Water Company,
La Sierra Water Company,
Sunny Slope Land Company,
Alta Mesa Water Company,
Union Water Company,
Salazar Water Company.

The distribution systems of water companies consist of cement or concrete lined canals, and cement and steel pipe. The Bear Valley Mutual Water Company used some redwood stave pipe for many years in Santa Ana Canyon, above the cement-lined canals, but the wood pipe is now being replaced with concrete. The Gage canal, 20 miles in length, is lined throughout with cement plaster, three fourths of an inch thick. The greater part of the Riverside Water Company's canals are lined. Steel pipe has been used for conduits under pressure; also for lateral lines under some of the systems.

Orchard irrigation systems are of cement concrete head flumes or underground pipe, with stands. Alfalfa is irrigated with detachable galvanized iron surface pipe and by flooding from open unlined field ditches and field borders. Power for pumping is usually furnished by electric motors or gasoline engines.

The duty of water for citrus fruits, stated in terms of depth on the land, varies in general from 1 to 2 feet; the higher figure being for systems receiving all or part of the water by gravity and with winter irrigation, and the lower figure for orchards where all of the water is pumped from wells and without much winter irrigation. The duty may also be stated as 1 miner's inch for 5 acres of citrus fruits at Riverside and Redlands. Under the Fontana system at Rialto, 1 miner's inch serves 7 acres of citrus orchard. A miner's inch is sufficient for 2 to 3 acres of alfalfa in San Bernardino basin and Riverside Valley, and the quantity of water applied to alfalfa is from 2 to 5 acre-feet per acre. Water is delivered to orchards by rotation under a thirty or forty-five day schedule. The rainfall at San Bernardino is 15.92 inches, at Redlands 14.94 inches, and at Riverside 10.46 inches, most of it occurring in late winter and in spring.

The principal areas where drainage is needed are along the Santa Ana River near Arlington and in the upper basin. Lower Riverside Valley lands have been damaged to some extent by return seepage water from the higher lands. Preparations are being made to drain some of this land.

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Some of the older ditches, such as those at Redlands, have been given fixed amounts of water from the streams by the courts. In general, rights have been adjudicated frequently, yet new cases of litigation are continually coming up, due to extended operations of the older companies, and to new appropriators entering the field. Companies have been desirous of owning riparian land, to strengthen their rights. Many companies and individuals claim riparian, appropriation, and prescriptive rights, appropriation being used in the sense of actually applying the water, and prescription with reference to the Statutes of Limitations. Redlands companies have been involved in much litigation in connection with the failure of the Bear Valley Irrigation Company, as well as over water rights in Santa Ana River. Several irrigation districts were organized under the State law in the eighties and all failed. Some of the litigation coincident with these failures, as in the case of the Rialto and Grapeland districts, was yet in the courts a few years ago. The courts have been called upon to settle questions of right to use water from the river, between the Orange County and the Riverside County canal companies. One of these important cases was compromised and withdrawn from trial. Questions have also arisen between the Riverside and San Bernardino County water users. Recently suit was brought by Riverside to restrain the Bear Valley Mutual Water Company from storing additional water in their new reservoir in the mountains. Litigation over rights to use underground waters and to convey underground waters to distant lands has followed as a result of the Riverside companies securing water from San Bernardino basin. The governing principles of late decisions relating to the use of underground waters were first laid down by the Supreme Court of the State, in *Katz* vs. *Walkinshaw*. A later decision in *Barton* vs. *Riverside Water Company* is more comprehensive. These cases have general application, inasmuch as the same questions may arise in any locality where there are disputes over rights to use underground water.

The Bear Valley Mutual Water Company completed a multiple arch concrete dam, about 85 feet high, costing about $300,000, in 1911, to replace the old Bear Valley dam. The new structure increases the capacity of the reservoir from 26,464 acre-feet to 65,000 acre-feet. Another reservoir site is located on the South Fork of the Santa Ana River. It is reported to have a capacity of 35,000 acre-feet. About 8,000 acres is being added to the citrus district of Rialto by further development of water in Lytle Creek Canyon and by boring of wells and installation of pumping plants by the Fontana Development Company. Large areas of land are being reclaimed on La Sierra Heights and in the West Riverside district by companies and individuals. The decision of the court in a late case brought by the Orange County water companies to stop the pumping of underground water from new wells was decided in behalf of the defendants. This will probably encourage pumping in the upper basins. An abundance of underground water is available, but it is difficult to estimate the

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amount that can be pumped without reducing the supply for Ora
County. The discharge of the river at Riverside narrows and
Rincon has held up well during the dry season in late years, notw
standing the increased diversions in the upper basins, and it app
that return waters from irrigated land have in a measure the effec
regulating the summer flow of the river.

The Gage Canal Company is now constructing a dam across Mock
bird Canyon to store flood waters.

Storm waters from Santa Ana Canyon and Mill Creek are spr
over the gravels north of Redlands with good effect, by the River
and Orange counties water companies. From 10,000 to 12,000 min
inches for about 100 days are diverted from the streams and put
the gravels when the snow is melting in the mountains. At the req
of the association conducting this work, the Government has reser
1,100 acres of land below Santa Ana Canyon for the use in stor
flood waters. The work has been very beneficial in maintaining a h
level of ground water in the San Bernardino basin, and in increas
the supply to users below. The president of the association has e
mated that the supply to the Riverside canals alone amounted to 1,
miner's inches last year. The level of the underground water wa
feet higher than in previous years. Flood waters are also spread o
gravels at the mouth of Lytle Creek Canyon, by the Fontana Deve
ment Company. The method employed here has varied somewhat fr
that employed in other localities of southern California. Water diver
from the stream channel is conducted to vertical shafts excavated
the gravel of the débris fan to depths of 50 feet or more.

The mean annual discharge of the Santa River near Mentone, f
1896 to 1910, was 59,200 acre-feet.[1] The river has 483 square mile
mountain watershed above Colton. It is estimated that the area i
gated in this territory may be increased 10,000 acres from furt
development of underground waters, and an additional 10,000 acres
storage in the mountains. It would be possible to deliver water r
San Bernardino from Arrowhead reservoir, located in the Mojave R
drainage, by tunnel through the San Bernardino Range. This disp
tion of the water has been considered, but the indications at pres
are that the stored water will be used on the northern side of
mountains. This reservoir will furnish sufficient water for the irr
tion of about 15,000 acres of orchard.

Electrical power is developed in Santa Ana, Mill, and Lytle cany
Power development is all above diversions for irrigation, and the
uses do not conflict. Power is also developed by the Riverside Wa
Company and at a plant between Arlington and Corona.

YUCAIPA VALLEY AND SAN GORGONIO PASS.

San Gorgonio Pass is between the San Bernardino and San Jac
mountains and connects San Bernardino Valley with Coachella Des
The elevation of the divide is 2,500 feet. Yucaipa Valley is at the

[1]U. S. Geol. Survey, Water Supply Paper No. 300.

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of Mt. San Gorgonio and has a mean elevation about the same as the pass. It is connected to the pass near Beaumont and is separated from Redlands by Crafton Hills. The pass includes 24,400 acres of tillable land, sloping to the west, and 29,200 acres sloping to the east. The area irrigated is 5,230 acres, the greater part being near Beaumont and Banning. Yucaipa Valley contains 18,400 acres, of which 2,500 acres are irrigated.

The water supply of San Gorgonio Pass is from San Gorgonio, Little San Gorgonio, Noble, Potrero, and Millard creeks, all from San Bernardino Mountains. Little San Gorgonio and Noble creeks drain towards San Timoteo Canyon, while the others drain eastward to the Whitewater. The northern slope of the San Jacinto Mountains is more precipitous than the southern slope of the San Bernardino Mountains, and there are no streams from the south that furnish any material amount of water for irrigation. The streams are torrential in character, although most of them discharge some water throughout the year. The normal flow, if not diverted for irrigation, would all be absorbed by the gravels. The gravelly channels of the washes indicate that flood waters sometimes cross the land, the wash of San Gorgonio River especially being evident. The eastern end of the pass drains to Coachella Desert and Valley and Salton Basin by way of Whitewater River. The western drains through San Timoteo Canyon to San Bernardino Valley.

The streams entering Yucaipa Valley are Potato, Water, and Wildwood canyons. The valley is drained by Yucaipa Creek to San Timoteo Canyon. The valley and pass are visited with too much frost for the growing of citrus fruits, but they are adapted to apples, pears, cherries, figs, and other deciduous fruits, while almonds have been grown successfully. The summers are cool, owing to the elevation and the proximity of snow-capped mountains. There is a marked change in temperature at the eastern end of the pass, where it partakes of conditions prevailing on Colorado Desert. The difference gives rise to winds which rush through the pass from the coast region to replace the heated atmosphere of the desert. The winds become more pronounced toward the east, where they render this end of the pass, together with the desert beyond, almost useless agriculturally.

Soils in the pass range from sandy loam to gravel. Some of the unimproved land near Cabezon is held in large tracts, but most of the improved land is in tracts of about 20 acres.

The upper or bench lands of Yucaipa Valley are of sandy loam, sloping 200 feet per mile to the west. The lower, and more properly the valley lands, are loamy. Ground water is brought to the surface in the lower area and good wells are secured by boring to comparatively shallow depths.

Apples are grown in Potato Canyon and miscellaneous crops in lower Yucaipa Valley, but the major portion of the valley has produced nothing but grain for many years. The South Mountain Water Company of Redlands developed water in canyons above the valley, and

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after using the water for five years, suit was brought by the Yucaip Land and Water Company, owners of the Dunlap ranch, to stop th taking of water to Redlands. The court limited the South Mountai Company to fifty-two and one half miner's inches. In 1910 the Red lands and Yucaipa Land Company acquired the property of th Yucaipa Land and Water Company, including the Dunlap ranch. Th South Mountain Company now receives the amount awarded by th court from the system of the Redlands and Yucaipa Company an from wells in the lower valley in exchange for rights in the mountai canyons. The Redlands and Yucaipa Company is increasing its wate supply by further developments in the canyons with tunnels and well and has constructed a small storage reservoir commanding their dis tributing system of underground pipe. The water supply, if a conserved, is claimed to be sufficient for 11,000 acres on the basis o 1 miner's inch for 10 acres.

The Beaumont Land and Water Company supplies 1,900 acres wit water from Edgar and Noble canyons, 2 artesian wells, and 3 pumpe wells. The total maximum supply is approximately 450 miner's inche Water from the canyons is conveyed in steel pipe, there being a tota of 50 miles of pipe including the distributing system. The steep grad of the main conduit allows 65 electrical horsepower to be generated fo pumping water from wells. The Banning Water Company takes wate from San Gorgonio Creek by means of a small concrete dam and miles of ditch, lined with rubble masonry, and with a capacity of 90 miner's inches. The main conduit leads into 2 small concrete-line reservoirs situated above a distributing system of steel pipe. Th Malone Land and Water Company is at present irrigating 180 acre near Cabezon from Millard Canyon. Water rights are based on th long-continued use of water and on riparian land.

The Beaumont Land and Water Company allows 1 miner's inch fo 10 acres. The land irrigated is principally in young deciduous tree The practice under the Banning system is to use 1 miner's inch fo 6 to 7 acres of deciduous orchard.

The Consolidated Reservoir and Power Company is at present con structing a ditch to convey water from Whitewater River to land near Banning, a distance of 6 miles. The water will be diverted at a elevation of about 7,000 feet and opportunity will be given to develo a large amount of electric power before the water is used for irrigation The conduit will have a capacity of 900 miner's inches. In additio to this conduit, a storage dam is to be constructed in Whitewate Canyon. As the discharge of Whitewater River is all absorbed in it attempt to cross Coachella Desert, and as undoubtedly this stream i the source of the underground water in Coachella Valley, diversion from Whitewater Canyon for lands in San Gorgonio Pass will probabl affect the water supply of Coachella Valley. Irrigators at Coachell are protesting against the contemplated diversion by the Consolidate Reservoir and Power Company.

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Of the watershed draining directly into San Gorgonio Pass that going westward is 50 square miles, practically all of it being on the north side. That drainage eastward is 145 square miles, that on the north side, 82 square miles, being the most valuable for water supply. The rainfall at Beaumont and Banning is about 16 inches and that in the mountains is much greater.

Storm waters from San Gorgonio Creek have been spread over the gravels of the wash below the canyon with good effect. The average flow of this stream is reported to be 550 miner's inches. It is the largest stream entering San Gorgonio Pass.

It is hardly probable that more than one fourth of the land in San Gorgonio Pass will be irrigated. Some increase should take place from further draft on the underground waters. Most of the wells now existing are located along the north side of the pass near Beaumont and Banning. Some of these flow and others must be pumped. In a new well drilled by the Beaumont Land and Water Company, the water began to flow on reaching a depth of 72 feet below the surface. Another well of this company in Edgar Canyon discharges 55 miner's inches, the water being lifted over 200 feet. The area to be irrigated in Yucaipa Valley is 11,000 acres.

SAN JACINTO VALLEY AND CORONA.

San Jacinto River drains the southwestern slope of San Jacinto Mountains and after crossing a broad valley somewhat broken by hills, empties into Lake Elsinore. In periods of high precipitation the lake overflows by way of Temescal wash to Santa Ana River near Corona. The chief areas of agricultural land in this drainage are San Jacinto Valley proper, including the territory around San Jacinto, Hemet, Winchester, Lakeview, Perris, and Moreno, the mountain valleys south of the main basin, the valley adjacent to Lake Elsinore, the rolling land of the El Sobrante ranch, and the Corona citrus district. San Jacinto Valley is higher than Riverside and is separated from it by hills. The areas of agricultural land and irrigated land are: San Jacinto Valley, agricultural 249,700 acres, irrigated 23,112 acres; Corona, agricultural 18,500 acres, irrigated 6,750 acres.

Most of the soils of San Jacinto Valley are loams, containing some sand and gravel in places. Some adobe is found and some alkali in low places, such as near Mystic Lake northeast of Lakeview. Most of the mesa soil is reddish in color and resembles the lands of Riverside and Redlands. Hardpan is present in some localities. The El Sobrante grant contains 21,000 acres of good land. The Corona mesa is sandy loam adapted to citrus culture and sloping to the north at the unusually high rate of 300 feet per mile. Most of San Jacinto Valley has been producing grain for many years. Orchards are from 5 to 20 acres in extent; alfalfa ranches from 20 to 200 acres; and grain ranches sometimes contain from several hundred to several thousand acres.

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Water for irrigation is furnished users at San Jacinto and Hemet at fixed rates, by public service companies. The Citizens Water Company, which recently acquired the property of the old San Jacinto Water Company, supplies 2,700 acres of citrus and deciduous fruit orchard near San Jacinto, and the Lake Hemet Water Company, and Fairview Land and Water Company supply 5,300 acres of orchard land near Hemet. The Hemet system receives water from the Lake Hemet dam on the South Fork of the San Jacinto River. This structure is 125 feet high, of masonry, and the reservoir has a capacity of 8,000 acre-feet. The Citizens Water Company secures water from a perforated collecting pipe or gallery in the mouth of San Jacinto Canyon, and from wells. The duty of water under the Citizens and Hemet systems is 1 miner's inch for 5 acres. Water is conveyed through cement pipes and cement-lined ditches.

The rate under the Citizens company is $3 per acre per year and under the Lake Hemet Water Company $2 per acre per year. The rate of the Lake Hemet Company has not paid operating expenses and it will probably be raised.

The Moreno Valley Water Company supplies water from wells to 400 acres near Moreno and water is conveyed from Mill Creek near Redlands to 450 acres near Allesandro through Allesandro pipe line. Aside from these water companies there is much irrigation from private plants scattered throughout the valley, although the greater number are near San Jacinto and Elsinore. Alfalfa is the principal crop irrigated from pumping plants. Olives and English walnuts have been grown near Elsinore and Wildomar in late years. The olive is the only unirrigated crop aside from grain.

The companies at Corona are mutual organizations. The Temescal Water Company furnishes water for 4,682 acres of citrus lands. The water is secured from branches of Temescal Canyon, twelve pumped wells in Perris Valley, and one flowing well. Electric power is generated at a steam power plant near Ethenac and transmitted to the pumping stations. Water is conveyed by two pipe lines by way of Temescal wash to Corona. One miner's inch has a value of $1,000 and serves 5 acres under the Temescal system. The cost of water to the user is $24 per acre per year. Water is delivered according to a thirty day rotation.

Other companies near Corona are the Foothill Lemon Company and Corona Pumping Company, which secure water from wells. The latter is for alfalfa lands.

The Cajalco Water Company furnishes water for the irrigation of lands on El Sobrante ranch. Water is secured from Cajalco or Hoag's Canyon.

Much of the irrigation of alfalfa in San Jacinto is from pumping plants and artesian wells. An artesian area, originally 14 square miles, stretches northwestward from San Jacinto. The area has contracted

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at its upper end owing to the drafts made on the basin by wells and to the dry period ending about 1906, but many wells still flow. Where the flow is light, the wells are pumped. The older wells were usually from 100 to 300 feet in depth, but during the last few years some deeper wells have been drilled and these yield good flows. The deepest is 700 feet, which is reported to deliver 65 miner's inches. The artesian basin owes its existence to Lakeview Mountains which intercept the underground water in its passage westward from San Jacinto Canyon. In other parts of the valley underground water is usually found at depths of 10 to 50 feet. Water must be lifted about 10 feet near Perris, while originally it stood practically at the surface of the ground. In other wells about 300 feet deep the pumping lift was 65 feet, in 1912. Water can be secured at depths of about 30 feet, at Moreno, also south of Elsinore. Many wells deliver 100 miner's inches each. Wells near Lakeview are about 200 feet in depth but do not stand much pumping. Underground water has not been found in Diamond Valley.

Several thousand acres of land along San Jacinto River near Lakeview and around Mystic Lake are subject to overflow during the winter and would be improved by drainage. Some alkali is present in these lands, but they have been used for sugar beets and pasture.

The Perris, Allesandro, and Pleasant Valley irrigation districts were organized soon after the passage of the State irrigation district law, but all failed, through insufficient water supply, mismanagement of funds, or other causes. Some of the questions relating to the validity of the bond issues of these districts are yet in the courts. The Lake Hemet Water Company claims all of the flow of the South Fork of San Jacinto River at the Hemet reservoir. The San Jacinto Water Company, which has now been superseded by the Citizens Water Company, purchased the rights of the old Pleasant Valley Irrigation District. The taking of water from Perris Valley for use at Corona led to litigation, in which the Temescal Water Company was limited to 850 miner's inches from this source, by the court.

The Lake Hemet Water Company may increase its acreage to 8,000 acres, provided additional water can be secured from wells. The Citizens Water Company has lately increased its water supply by the drilling of new wells near San Jacinto, and are now in a position to irrigate 4,000 acres, or an increase of 1,300 acres over the present area. A large increase in the irrigated area of San Jacinto Valley may be expected from the development of underground water. Many new wells are being bored and pumping plants are installed every year.

The Superior Land and Water Company expects to be able to deliver about 350 miner's inches from wells and pumping plants near Lake Elsinore for use on a tract of 2,000 acres of land. In 1912 underground water was developed in the cienega two and a half miles above San Jacinto. This cienega has been drawn upon by the collecting gallery of the Citizens Water Company, but its underground waters were not

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developed by wells until within the past year. It gives promise yielding a large amount of water which may be used advantageously the upper portion of the valley. The Ramona Power Company m filings in 1911 on the north fork of the river, Strawberry Creek, Massacre Canyon. It is proposed to construct a storage reservoi Strawberry Creek, where a suitable site has been located, and a utilizing the water for the generation of electric power under an 1 foot head, convey it to the lands in San Jacinto Valley.

As all of the discharge of the river and its tributaries during the gation season is claimed and used, only flood water will be available storage. Lake Hemet has a drainage area of 50 square miles on south fork and the capacity of the reservoir is 750 acre-feet and s cient for the storage of the entire run-off in a normal year. Some y the water overflows the dam. The entire mountain watershed of river is approximately 700 square miles and that portion drained the north fork and Strawberry Creek is a much more valuable waters than that of the south fork.

Water for the rolling land on Rancho El Sobrante de San Jac must be secured by pumping from wells. This property has been divided and is being colonized. The irrigated area at Corona is b extended by companies pumping water. The Foothill Lemon Comp will supply 820 acres.

Lake Elsinore, into which San Jacinto River floods are dischar has an area of 7 square miles. The waters of the lake, like most inl bodies of water, are too saline for irrigation. The loss of wate equivalent to about 5 feet in depth annually.

Plans have been proposed for the utilization of Lake Elsinore storage reservoir and the waters of the lake have been filed upon. successful plan involves the reduction of the percentage of salt in water and it is not certain that this is practicable.

ORANGE COUNTY COASTAL PLAIN AND MESA.

This area includes all of Orange County excepting La Habra w is topographically connected with the Whittier district of Los Ang County. The largest agricultural area in Orange County is the coa plain, which is a continuation of the Los Angeles coastal plain tow the southeast. The land has been formed by the alluvium from Sa Ana and San Gabriel rivers, together with marine deposits. The n in the southern part of the county differs in character from the coa plain and valley below Rincon. Other agricultural areas are along Juan and Trabuco creeks near the San Diego County line. Ora County, though small, has comparatively little waste land. It ha total of 460,000 acres and of this 204,500 acres is classed as agricultu The main district may be divided into three parts, one of 44,500 a including valley above the coastal plain, bench lands bordering the h and the upper part of the coastal plain itself; a second compri

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80,000 acres of lower land principally in the artesian area; and a third 80,000 acres of mesa land. The upper area is devoted chiefly to the growing of citrus fruits although many English walnuts and some deciduous fruits are produced. The lower coastal plain contains large areas of sugar beets and celery, onions, potatoes, peanuts, alfalfa, corn; some deciduous fruits, and berries are also grown. The main crop on the mesa land is lima beans. Formerly dry-farmed grain was the principal crop. The hills north of Santa Ana Valley constitute one of the important oil-producing fields of California.

Much sandy and silt loam mixed with gravel is in evidence on both sides of Santiago Creek about Santa Ana, Orange, El Modena, Villa Park, and Tustin.[1] A large portion of the plain west of the river and around Anaheim and Garden Grove is classed as sandy loam and sandy adobe. These soils also occur on the mesa southeast of Tustin. South of Santa Ana and Tustin is an area of black adobe. Sand and sandy adobe are found back of Newport Bay and peat occupies limited areas near the ocean. Some of the black adobe soils south of Santa Ana and Tustin and in the marshes southwest of Fairview contain over 3 per cent of alkali. Small areas south of Anaheim and east of the river contain salts in amounts varying from .6 per cent to 3 per cent. The greater portion of the county does not have salts in excess of .2 per cent.

As in other parts of southern California, practically all valley land in this county was originally in Spanish grants. One of these now, the Irvine ranch, contains 109,000 acres and occupies the mesa south of the coastal plain. Holdings in the orchard district average about 10 acres while in the low lands they vary from 10 to 160 acres, 40 acres being common.

Orange County has the Valencia orange and the English walnut among orchard products. All crops in Orange county are irrigated excepting grain and beets. Sugar beets are not irrigated with regularity and grapes are irrigated in dry years only. At one time there was a large area in vineyards but this has been gradually reduced until very few acres are now devoted to that industry. Rotation of crops is much practiced below Anaheim and this often results in a change of the use of water from one tract of land to another from year to year. Some land owners who formerly depended upon shares in water companies have now disposed of their stock and depend upon pumping plants.

The citrus district of Orange County is furnished water by five irrigation systems. The surface water of the Santa Ana is divided equally between the Santa Ana Valley Irrigation Company and the Anaheim Union Water Company at a joint division weir in Bedrock Canyon just below the Riverside-Orange county line. The Anaheim Union canal leads from this weir along the base of the northern hills and covers 8,100 acres of land on the northwest side of the river about Anaheim, Fullerton, and Placentia. The water going to the Santa Ana Valley

[1] U. S. Dept. Agr., Bureau of Soils, Soil Survey of the Santa Ana Area, Cal.

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Irrigation Company follows the river channel for a distance below division weir before being diverted into the canal. This canal is for to follow close to the river channel until it has passed the point of l at Olive. From here laterals branch southward covering 17,200 a about Orange and Santa Ana, nearly all in citrus and walnut orcha Both canals are cemented in large part. In late years the flow of t has been augmented by pumping plants taking water from wells r Horseshoe Bend, several hundred miner's inches being developed each company in this way. The Anaheim Union Water Comp secures additional water by pumping wells between Fullerton and l centia. The Yorba reservoir is used in connection with this compar canal for the storage of surplus water not needed directly for irrigat This reservoir has not been as serviceable as was anticipated, parti on account of a large loss by seepage, but it is probable that the b will be lined with cement. The Santa Ana Valley Irrigation Comp also has a distributing reservoir on the lines of its canal near Olive wh has given good service as a regulator to the distributing system. Th two companies use all of the normal flow of Santa Ana River and th are no diversions below their canals. It has been proposed to constr a submerged dam across the river at Sculley's Point as a permar joint heading for the canals in an endeavor to secure the subsur flow of the river more completely than is now done. The present w of the companies is often destroyed or damaged by heavy floods in winter time and must be reconstructed or repaired at the beginnin each irrigation season. Both companies are mutual organizations, stock being made appurtenant to the land by the company by-la Distributing laterals under these companies are usually small cem lined ditches. The waters of Santiago Creek, the chief tributary of Santa Ana, are also divided equally between two coöperative water c panies. The Serrano Water Company serves 1,050 acres on the no side near Villa Park and the John T. Carpenter Water Comp supplies 750 acres on the south side near El Modena. A submer dam which is one of the few that intercept all underflow was c structed across Santiago Creek at Point of Rocks jointly by the Serr and Carpenter water companies. This enables most of the subsur flow, as well as the surface flow, to be diverted. The water is car by pipe line to a division box from which point equal parts go to companies. The only other ditch receiving water from the river its tributaries is the Yorba ditch which irrigated 627 acres in Sa Ana Canyon. This ditch has the oldest right to water from the r in the county. It is situated below the Anaheim Union Water C pany's canal and originally diverted water directly from the r but now receives its supply through the Anaheim Union canal.

The other water companies in this part of the county are small org izations pumping water from wells. The lower part of the coa plain depends on the underground water for irrigation. Sev

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hundred pumping plants and flowing wells are drawing on the underground supply. The artesian area within the county at one time covered 38 square miles. In general there has been a gradual reduction in the water level during the past fifteen years and in some wells the water is 20 feet lower than formerly. This reduction carries with it a contraction in the artesian area along its upper edge. Here many wells have ceased to flow and must now be pumped while the discharge in some of the lower shallow wells has been diminished. The lowering of the water level has, however, been slight the past four or five years. While shallow wells have a diminished output, deeper wells reaching to lower artesian strata are producing large flows of water. The underground water no doubt comes chiefly from Santa Ana River. That underlying the northwestern portion of the county may come in part from San Gabriel River. The lessened decline since 1906 is due to the heavy precipitation of the late period with increased discharge of Santa Ana and San Gabriel rivers. A new well of the Holly Sugar Company near Huntington Beach reaches a depth of 521 feet and is one of the deepest in Orange County. It produces a good artesian flow. Single wells in Newport produce 75 miner's inches. The majority of the wells are from 150 to 300 feet deep.

Most of the land near the coast required drainage before it was suitable for cultivation. Four drainage districts under the State law have been organized and three of these already have systems in operation. The Bolsa district drains 2,400 acres near Smeltzer and Huntington Beach. Much of this land is peat and now produces the finest quality of celery. The crop for the past year brought the growers in the association $398,155. The Talbert drainage district covers 10,000 acres and the Delhi district 5,000 acres. The Newport district has been organized and will drain 3,000 acres. The section about Alamitos also needs drainage in order that the best results may be secured agriculturally and it is probable that a system will be constructed in due time. Sugar beets constitute the main crop on the low, moist lands and beet sugar factories are located at Alamitos, Anaheim, Santa Ana, and Huntington Beach. Farms are tile drained to connect with the main drainage ditches. In addition to the drainage districts, the Newbert Protection District has been organized for the protection of 1,800 acres of land along the lower Santa Ana by confining the flood waters of the river to the main channel by levees. The large floods of the rainy season, unless controlled, spread over a large area of land and cause damage to property. Some of the alkali lands near the coast have been reclaimed by leaching the salts by flooding the surface in connection with tile drainage.

Water rights in Orange County have been fairly well settled as among the appropriators in the county itself. Litigation was in progress during the early period of the organization of the Anaheim and Santa

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Ana companies which continued for a number of years and cost thousands of dollars. The disputes were finally settled by agreement providing for the equal division of water as now practiced. The respective rights of the Serrano and Carpenter water companies to use water from Santiago Creek were established by a decision of the superior court rendered in 1896. In late years trouble arose between these companies and the Irvine ranch owners over the use of water from the creek but a compromise was effected by which the two water companies which had long appropriated and used the water were to have a maximum of 600 miner's inches during five months of the irrigating season and 60 miner's inches for the remainder of the year divided equally between them, and the Irvine ranch was to have the surplus. This leaves the Irvine ranch to depend largely on the winter flood waters and as there is no storage the ranch is not fortunate in having a good water supply for irrigation. About 200 acres are, however, irrigated. The Serrano and Carpenter water companies have for years spread flood waters over the gravels in Santiago Canyon above their joint submerged dam with the result that the subsurface flow reaching the dam is regulated and increased in the dry season, whereas without such spreading the water would run to the sea unused. A reservoir site of about 35 acres in area is in Fremont Canyon, a tributary of Santiago Creek.

The duty of water under the Orange County companies varies from 1 miner's inch for 5 to 10 acres, more water being used on citrus than on deciduous and walnut orchards. Under pumping plants and wells the irrigation is more irregular and as a rule there are a less number of irrigations where the water is pumped than under the gravity systems.

A suit was brought to restrain the pumping of water along the river above Corona, the Orange County companies claiming that the subterranean flow of the river was being drawn upon and that this directly reduced the supply reaching their canals. The court held that the water drawn from the wells was percolating water which saturated lands in the upper basin and that it was not directly connected with the stream and the taking of this water away for use on non-riparian lands was not forbidden.

All of the discharge of Santa Ana River during the irrigating season is diverted and used. All water entering the San Bernardino basin from Santa Ana Canyon is diverted for use in San Bernardino and Riverside counties and some water is pumped in this basin to supplement the flow of the canals. The winter floods store a large quantity of water in the gravels of this upper basin and the river has a large underflow which is well regulated through the summer. The underground water is brought to the surface at several points along the river's course, one being in the pass below Rincon. The underground

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vater receives additions from other streams, such as Temescal Wash nd Chino Creek, discharging into the large basin above Rincon. Approximately one half of the supply of the river is diverted in the ipper basin near Colton. In late years the summer flow in the lower river has held up better than in former years and this indicates that return seepage waters from irrigated lands in the upper basins have he effect of regulating the flow on the lower part of the stream. The Bear Valley Mutual Water Company of Redlands stores 40,600 acre-feet in their reservoir in San Bernardino Mountains. The underground water level in San Bernardino basin was 5 feet higher in 1911 than in the previous year. The run-off of Santa Ana River depends more on the rainfall in San Bernardino Mountains than on any other watershed.

Miscellaneous measurements of the Santa Ana at Rincon from 1898 to 1906 show a mean discharge of 118 cubic feet per second.[1] It is estimated that fully this amount is being used in Orange County by the canals taking water directly from the river and by the pumping plants and artesian wells. San Juan and Trabuco creeks have a combined annual discharge of from 5,000 to 6,000 acre-feet. This is all used by the Trabuco and Capistrano water companies. No storage sites are reported on these streams.

It is probable that the area irrigated in the county might be increased a comparatively small per cent of the total by a more economical use of water and through greater precaution in preventing waste during the winter. At present 51,000 acres are irrigated in the county, excluding La Habra. This is divided as follows: Citrus district 39,000 acres, low lands of coastal plain 7,000 acres, and mesa lands 5,000 acres.

Summary for Santa Ana River Lands.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
Pomona Valley and Cucamonga Plains	131,448	44,823	55,000	Underground waters.
San Bernardino Valley and Riverside	200,523	79,992	100,000	Storage on Santa Ana River and tributaries and underground waters
Yucaipa Valley and San Gorgonio Pass	72,000	7,730	24,000	Storage on Whitewater River canyons above Yucaipa Valley and undergrounds waters.
San Jacinto Valley and Corona	268,200	29,862	40,000	Storage on San Jacinto River and Strawberry Creek and underground waters. Underflow of Santa Ana River and underground waters.
Orange County	204,500	51,000	60,000	
Totals	876,671	213,407	279,000	

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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SAN DIEGO COUNTY.

In San Diego County, as in Santa Barbara and Ventura cou the problem of further development is largely one of the storag flood waters, but a distinguishing feature between this and the u counties is that the need of irrigation in San Diego County has n been questioned. Here the atmosphere is drier, the summer tem tures higher, and the precipitation and stream discharge less. discharge is also more erratic, for the more arid the country the gr the variation of precipitation from the normal. The maximum charge for some years may be several times the normal, while in years the catchment in reservoirs has been almost nothing. T conditions must be contended with and they account in some mea for flood waters not being completely stored at the present Capacity must be provided for the storage of the combined floo two or three years for the best utilization of the water resources. makes the stored water costly, but its value for irrigation justifi unusual expense. Opportunity is given for the development of po without interference to irrigation, in connection with almost e storage project, and recently investment in storage works has encouraged by the increasing demand for electrical power as we by a rise in the value of water for irrigation. Another factor in development now taking place is the need of San Diego for dom water. Underground waters have not been fully developed, alth they are drawn on more heavily than in Santa Barbara and Ven counties.

SANTA MARGARITA VALLEY AND FALLBROOK.

Santa Margarita River is most northern of the streams of San D County. Part of its headwaters is in Riverside County. Its branch above Temecula Canyon where the waters pass through coast range is known as Temecula Creek. The mountain country a the canyon contains small basins with rolling land ranging in eleva from 1,000 to 3,000 feet above sea level. Among them are Teme Murietta, French, Los Alamos, Glen Oak, Wilson, Terwilliger, Coahuilla valleys, situated in Riverside County, and Oak Grove V in San Diego County. These mountain valleys are used for grain pasture. Aside from 600 acres in Temecula Valley, only a few a are irrigated in the mountain country. The elevation is too grea some crops. The valleys are so near the source of the streams sufficient water is not available for the land. Water is taken Temecula Creek for use in Temecula Valley, by temporary dams re each year. Four flowing wells are located on Rancho Pauba and are located near Murietta. Alfalfa is the principal crop irrigated

Santa Margarita Valley is 12 miles long and has an average w of three fourths mile. Much of the land is in grain. Twelve hun acres of alfalfa on the Home ranch is irrigated from a small sto reservoir in the upper end of the valley. Sugar beets were grow

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150 acres without irrigation in 1912. This valley is rolling and has dark loam soil with a light adobe in places. The land becomes somewhat marshy and alkaline near the coast. The entire valley is a part of the Santa Margarita grant of 260,000 acres not yet subdivided.

The Fallbrook area is devoted chiefly to grain, but small areas of citrus fruit, garden truck, and alfalfa are grown by irrigation. The land is rolling and hardpan is usually found within a few feet of the surface. Efforts were made to organize an irrigation district for Fallbrook at the same time the Escondido district was launched, but the project got no farther than preliminary organization. Water for irrigation is secured by pumping from wells. The underground supply has not been well determined, but indications are that it is not abundant. The country about Fallbrook can be supplied with water from either the Santa Margarita or the San Luis Rey. The proposed Pauma reservoir, if constructed on the latter stream, would be in a position to serve this territory, although it is probable that the water available from the San Luis Rey might be used to better advantage on lands along that stream. Some development may be expected in Santa Margarita Valley from pumping underground waters, as the supply is good. The conditions for underground waters are also good in Temecula Valley, but this is the only one of the mountain valleys that may be expected to develop by irrigation. A reservoir site is located on the Santa Margarita at the junction of Temecula and Murietta creeks. By constructing a dam across the narrow gorge at the upper end of Temecula Canyon water could be stored in a large basin above. The flow of Temecula Creek, however, is small and loss by evaporation would have to be considered. It is not certain that the water supply would justify construction, as the water would have to be carried 10 or 15 miles by a pipe to reach Fallbrook or Santa Margarita Valley. The watershed above Temecula Canyon is 120 square miles, but it contains more rolling than mountainous country. A large portion of the land on the lower stream could be irrigated provided the flood waters were conserved.

Santa Margarita Valley contains 6,272 acres of agricultural land, Fallbrook 12,800 acres, and the mountain valleys 95,000 acres, a total of 114,072 acres. The areas irrigated are as follows: Santa Margarita Valley 1,200 acres, Fallbrook 122 acres, and mountain valleys 310 acres, making a total of 1,632 acres.

SAN LUIS REY, ESCONDIDO, AND SANTA YSABEL VALLEYS AND LINDA VISTA MESA.

Under this heading is included all of that portion of San Diego County lying between Santa Margarita and San Diego rivers. The total area of agricultural land is 154,498 acres, and of this 4,995 acres are irrigated. The San Luis Rey and the Santa Ysabel are the only streams in this territory which rise in the high mountains of the eastern part of the county. Escondido Creek drains a small territory between the two rivers. San Marcos, Los Penasquitos, and other small creeks

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cross the mesa near the coast, but are not of much consequen
regards water supply. It is convenient to consider all of this p
of San Diego County together because development of the num
small valleys and coast bench lands depends on the constructi
irrigation systems involving the water supply of the several dra
basins.

The only portion that is already well developed is Escondido V
This district contains 13,500 acres of agricultural land and is p
cally on the divide between Escondido Creek and Santa Ysabel
although the greater portion of the area slopes toward Escondido
The irrigation system here was begun under the Escondido Irri
District and completed by the Escondido Mutual Water Com
which succeeded the district. The district, which experienced the
troubles of the early irrigation district organizations, transferr
property to the mutual company on the basis of $225,000 valu
the actual cost at the time being over $400,000. The district inc
13,000 acres and 853 acres are now irrigated under the mutual
companies' system. The principal source of water for Escondi
San Luis Rey River, from which stream 3,000 miner's inches was
on. The water diverted is carried by open ditch, tunnel, and
across and through the divide to the headwaters of Escondido
A tunnel is now being constructed to replace 1,900 feet of flume.
important feature of this system is the Escondido dam, a loose
fill, lined on the upper face with redwood plank and constructed
height of 76 feet on one branch of the creek, giving a storage cap
of 3,500 acre-feet. The water stored is delivered to members o
mutual company in proportion to stock. The duty of water unde
system is 1 miner's inch for 10 acres. The charge is 10 cent
miner's inch for twenty-four hours. Oranges, lemons, grape
raisin. wine and table grapes, vegetables, and alfalfa are irrigated.

The important areas of agricultural land in the San Luis
drainage are Warner's ranch, Bear Valley, and San Luis Rey V
Warner's ranch is a tract of 44,500 acres occupying a mountain
36 miles back from the Pacific coast. The land is rolling and use
grazing. Numerous small streams which drain into the basin
the north, south, and east, where they unite either on the surface
underground water, form the San Luis Rey River. This drainа
all concentrated at the canyon of the river which gives an outlet t
basin toward the Pacific, and at this point is located the Warner
site.

Bear Valley is located below Warner's ranch and south of the
at the divide between the San Luis Rey and Escondido Creek drai
It contains 11,800 acres of agricultural land and 200 acres are
gated. This area has been very little developed owing to the la
water and transportation.

San Luis Rey Valley borders the lower river. Two small compa
the San Luis Rey Irrigation Company and the Libby Ditch Com
have ditches from the river covering lands in this valley, and ther

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in addition a number of pumping plants. The irrigating company is a mutual organization, but the Libby Ditch Company is not incorporated. Water is available for irrigation only in the winter months, although the San Luis Rey is the largest stream in San Diego County. The crops irrigated are alfalfa, sugar beets, and vegetables. Several mountain valleys on the headwaters of San Luis Rey River are small and they have not been classed as agricultural land owing to the poor prospect of development. San Luis Rey Valley contains 25,600 acres of agricultural land and 2,147 acres are irrigated.

The principal areas of agricultural land on Santa Ysabel River are San Dieguito, San Pasqual, Santa Maria, and Green valleys. The Santa Ysabel is sometimes called San Dieguito River, this name being applied especially near the coast. It is also sometimes called the San Pasqual, in its middle course where it traverses San Pasqual Valley, while the upper river is known as Bernardo River.

San Dieguito Valley contains about 2,000 acres, of which 150 acres are irrigated, alfalfa being the principal crop under irrigation.

San Pasqual Valley contains 3,440 acres, of which 1,040 acres of deciduous fruits, alfalfa, and vegetables are irrigated. The soil is a light sandy loam and free from alkali. The holdings vary from 5 to 300 acres each. The irrigation is under the East San Pasqual Ditch Company and the West San Pasqual Water Company. Both are coöperative, but neither has been incorporated. The respective rights of these associations to water from the river have been defined in the case entitled *Huffner* vs. *Judson,* in the Superior Court in 1898. Both companies have been in litigation with riparian owners, but these questions are still unsettled. Water is diverted from the river by ditches, that on the east side irrigating 240 acres and that on the west side about 800 acres. Of the land on the west side 401 acres is entitled to all of the water going to the association during the irrigating season, but the remainder of the land receives water during the winter. A few artesian wells have recently been drilled in this valley.

Santa Maria Valley is located on Santa Maria Creek, the principal tributary of the Santa Ysabel. The valley contains 16,380 acres and 102 acres are irrigated. Lands in the vicinity of Ramona, the settlement in this valley, are held in 5 to 40 acre tracts, and the grain land at the borders in much larger tracts.

Green Valley lies south of the Santa Ysabel and is not adjacent to either the main river or an important tributary. It contains 2,450 acres, none of which is irrigated. The land is rolling and is underlaid with hardpan, as are most of the valleys of this region.

San Marcos Valley is northwest of Escondido. It contains 33,200 acres, of which 213 acres of citrus fruits and vegetables are irrigated. The unirrigated land is in grain. The land is rolling and is underlaid with hardpan of the same nature as that found at Escondido. The underground water is the supply for the irrigation of the small area receiving water.

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Poway Valley is 15 miles northeast of La Jolla and is drained to th ocean through Los Penasquitos Canyon. It contains 2,100 acres, o which only about 20 acres of citrus fruit and vegetables are irrigated The character of the land is similar to the other valleys of this par of San Diego County.

A strip of bench land borders the coast from the northern boundar of the county to the mouth of San Diego River, a length of 50 mile and with a width of not exceeding 3 miles at any point. This stri would be continuous except for the lagoons where the Santa Margarita San Luis Rey, Escondido, and Santa Ysabel rivers and other smalle streams enter the ocean. These lands slope gently towards the coas and are adapted to agriculture, although the ocean winds might no permit the growing of citrus fruits. The chief settlements along thi coast are Oceanside at the mouth of the San Luis Rey, Encinitas a the mouth of Escondido Creek, and La Jolla and Pacific Beach, resort near San Diego. The total area of the coast land is 24,960 acres, o which 270 acres are now irrigated. Some of the land is within larg Spanish grants. The crops irrigated are alfalfa, a few truck garden and commercial flower gardens in the vicinity of settlements. Th unirrigated lands are used for grain and lima beans.

Linda Vista Mesa contains 19,000 acres of good agricultural land an embraces a territory lying just north of Mission Valley on the Sa Diego River and just back of La Jolla and Pacific Beach on the coast The mesa corresponds in elevation to La Mesa and Lemon Grove o the south side of San Diego River and is above the coast bench. Th area is very broken in outline owing to numerous little canyons tha have been eroded by the streams running toward the sea. The soil i suitable for citrus fruits even though it has the characteristic hardpan The ocean breeze is less violent than at points immediately on the coast Years ago the Linda Vista Irrigation District was organized for territory of 4,200 acres embracing the mesa. Bonds were sold to th amount of $178,000. The Pamo, Santa Maria, and Dye Valley reser voir sites, together with the water rights and right of way for conduits were acquired and preliminary engineering work done. The distric failed, leaving the lands under mortgage and liable for interest on th bonds until recently, when the district was dissolved. Consequently no development occurred during this period. Much of the land wa not even dry-farmed and remained in its desert state with growth o brush and grass. Much of the soil is loamy and reddish in color, mixe in places with water-worn cobble. Alkali is not present in quantitie that would be detrimental to agriculture. There are some small hold ings, but a large portion of the land is held in tracts of thousands o acres. This land should be adapted to lemon culture, being situate much the same as Lemon Grove, Chula Vista, and other districts in Sa Diego County.

The development of the agricultural areas in this part of San Dieg County lying between Santa Margarita and San Diego rivers depend

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much on the action of the Volcan Land and Water Company. The operations of this corporation may be objected to by the Escondido water users who have vested rights in San Luis Rey River. The Escondido company owns land bordering the south side of the San Luis Rey and claims riparian as well as appropriation rights. The Volcan Land and Water Company contemplates the construction of Warner, Pamo, and Santa Maria reservoirs, together with the ditches and pipe lines necessary for connecting them into one system, extensive power development below the reservoirs, and delivery of the water for irrigation of Linda Vista Mesa and several valleys. Claims have been made to all of the unused waters of San Luis Rey and Santa Ysabel rivers above the reservoir sites. Construction of the Warner dam has been begun and rights of way have been secured and surveys are being made for the completion of the project. It is proposed to build Warner dam to a height of 60 feet, although the height can be increased to 100 feet. The reservoir has a watershed of 213 square miles, over which the rainfall is probably 30 inches. The company has estimated that the amount available for storage annually is 125,200 acre-feet. One of the greatest objections to the Warner site is the comparatively flat basin above the dam which will expose a large area of water surface and lead to high loss by evaporation. It is proposed to convey the water stored in the Warner reservoir southwestward across the divide to the projected Pamo reservoir in the valley by that name on Santa Ysabel River. This basin has a watershed of 114 square miles, the greater portion of which is from 1,500 to 5,000 feet in elevation. The amount available for storage annually is estimated by the company's engineer at 41,090 acre-feet. The outlet conduit from the Pamo basin is surveyed to continue southwestward through San Pasqual Valley and toward Linda Vista. The Santa Maria reservoir will be connected to the canal in San Pasqual Valley. This site has a watershed of 56 square miles with elevations of from 1,300 to 4,000 feet. It has been estimated that 8,700 acre-feet are available for storage, making a total of 174,990 acre-feet for storage by this system.

The discharge of San Luis Rey River for the period 1903 to 1910 at Pala is 50,000 acre-feet annually, and that for Santa Ysabel River at the head of San Pasqual Valley for the same period 38,500 acre-feet annually.[1] The Pala gagings on the San Luis Rey are, however, 24 miles below Warner reservoir. Gagings made by the Volcan Land and Water Company in December, 1905, and each month from January to June, inclusive, of 1906, also each month from May to November, inclusive, of 1911, show a mean monthly discharge varying from 1.2 to 765.9 cubic feet per second.

The capacity of the reservoirs of this system in acre-feet are: Warner 173,000, Pamo 44,000, and Santa Maria 12,000. The San Luis Rey and Santa Ysabel are subject to great extremes of flow and the floods of an occasional year may be several times the normal. For

[1] U. S. Geol. Survey, Water Supply Paper No. 300.

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this reason the complete utilization of the flood waters depend sufficient storage capacity to impound the waters of the great f and hold them for use in dry years. The total storage capacity templated is 229,000 acre-feet. The company proposes to divert 8 acre-feet annually.

If the Volcan system furnishes water for 43,000 acres it is prol that most of the land reclaimed will be on Linda Vista Mesa. irrigation of these lands must come from storage of flood wat underground water is not available on the mesa. Poway Valley 24 square miles of local watershed. It is estimated that 800 acres be irrigated from the Volcan system and local sources. The st water if not used elsewhere can be conveyed to Escondido, San Rey, San Dieguito, Green, San Marcos, and Bear valleys, also the bench lands. It is estimated that 3,000 acres in San Luis Rey V and 1,000 acres in San Dieguito Valley may be irrigated by the d opment of underground water alone. Bear and Green valleys but little local watershed and underground water is not sufficie give prospects of much development. About 500 acres might be gated in San Marcos Valley. It is possible that some undergr water in San Pasqual Valley is intercepted by the concrete subsu dam at the head of the San Pasqual ditches, but some pumping, tog with a higher duty of water, should lead to the irrigation of practi all of the valley, 1,200 acres. Santa Maria Valley and Warner's R both furnish reservoir sites and riparian land. Probably 300 may be irrigated in Santa Maria Valley. Prospects are not favo for irrigating more than 40 acres on the coast bench near Ocean It is estimated that a total of 51,600 acres may be irrigated in part of San Diego County, including 11,000 acres for Escon Power may be developed between the Escondido dam and distribu system.

SAN DIEGO RIVER VALLEYS AND MESAS.

San Diego River rises in the mountains near Julian and southwestward to False Bay, just north of San Diego Bay. Bou Creek, the outlet of Cuyamaca Lake, is one of the chief tributa The districts dependent upon this stream for water are El C Valley, the first basin crossed by the river after leaving the m tainous country; Mission Valley, which includes the narrow stri bottom land along the river flanked on both sides by mesas just n of San Diego, La Mesa and Lemon Grove, being the mesa south of river, and Spring Valley, a small area south of El Cajon Va Spring Valley lies within the drainage basin of Sweetwater River, is too high to receive water from that stream. It is possible to b water from San Diego River through Sweetwater Pass for use on area.

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The following table summarizes the areas of agricultural and irrigated land under San Diego River:

Summary of agricultural and irrigated areas under San Diego River.

Area.	Irrigated land. Acres.	Agricultural land. Acres.
El Cajon Valley	27,100	1,143
Mesa land	12,000	4,700
Mission Valley	3,000	1,000
Spring Valley	2,600	300
Totals	44,700	7,143

The soil of El Cajon Valley is of sandy loam with good drainage. The soils of Spring Valley are similar to those of El Cajon Valley. Mission Valley is low and flat and portions are sometimes flooded during heavy rains. The soil is fertile, but alkali is found in the lower marshy areas. La Mesa and Lemon Grove are elevated areas in which the drainage has eroded deep channels, leaving irregular-shaped areas of mesa extending out from the hills. Hardpan is present on these mesas, but it does not seriously hinder fruit-growing, as the hard stratum is readily broken up by blasting for the planting of young trees. The level portion of the mesa slopes westward at the rate of about 50 feet per mile.

Improved lands are held in tracts of 5 to 40 acres and the unimproved grazing land in tracts of several thousand acres.

El Cajon Valley, La Mesa, and Lemon Grove are supplied with water by the Cuyamaca Water Company, formerly known as the San Diego Flume Company. This system utilizes Cuyamaca Lake as a storage reservoir. An earthern dam was constructed to a height of 41.5 feet, increasing the capacity of the lake to 12,000 acre-feet. The mean annual run-off from the drainage above the basin is about 5,000 acre-feet. Water released from the reservoir follows Boulder Creek to the north fork of the main river, where it is diverted into a flume 36 miles in length. Lateral pipe lines are taken from the flume to supply lands in El Cajon Valley and La Mesa. Water rights under this system were sold at from $600 to $800 per miner's inch, 1 miner's inch serving 10 acres. The company is a public service corporation and charges an annual rental of $60 per miner's inch.

Two distributing reservoirs are located near the lower end of the flume. The upper or Cujomeco reservoir has a capacity of 36 acre-feet and the lower or La Mesa reservoir a capacity of 1,460 acre-feet. This company has one pumping plant in El Cajon Valley and others in Mission Valley which are operated in dry seasons to supplement the supply of water from the flume.

A variety of crops are grown in El Cajon Valley, including oranges, lemons, grape fruit, raisin and wine grapes, olives, berries, deciduous fruits, and vegetables. La Mesa and Lemon Grove are known for their lemon orchards. All the crops are irrigated.

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Alfalfa, sugar beets, and vegetables are grown in Mission Valley, water for irrigation being supplied by several small ditches and pumping plants. The Julian apple district is located in the rolling land at the headwaters of the north fork of San Diego River at an elevation of about 4,000 feet. Some other deciduous fruits are also grown here. Orchards at Julian are unirrigated.

Although Cuyamaca reservoir has more than sufficient capacity to store the ordinary run-off, some water can not be stored in years of high rainfall and there is a possibility of the dam being raised to increase the efficiency of the system. The watershed above the reservoir is 11.5 square miles. The annual rainfall over this area varies from 12 to 40 inches and the mean run-off is 5,307 acre-feet. The watershed drains a portion of Cuyamaca Peak, the highest point in San Diego County, reaching 6,516 feet in elevation, but the large area of water surface leads to a large loss by evaporation. The total loss between the amount stored in the reservoir and the amount delivered to users, including both evaporation from the lake and the loss from the flume, is about 50 per cent. The watershed above the intake of the flume is about 100 square miles. The waters of the north fork as well as those from the reservoir are taken by the flume. During flood season much water overtops the diversion dam and runs to waste except that it contributes to the underground reservoirs in El Cajon and Mission valleys. San Diego River is usually dry during fall and early winter. The Lake Helena or Dye Valley dam site is located on the north fork of San Diego River, about 1 mile above the head of the flume. The watershed above it is 80 square miles. A dam could be constructed to give a capacity of 10,000 acre-feet. The measurements of San Diego River near Lakeside for the period 1906 to 1910 show a mean annual discharge of 39,600 acre-feet.[1]

Further development of underground waters in El Cajon and Mission valleys is now taking place and considerable increase in the irrigated area should come from this source. Water is found at depths of 15 to 30 feet over El Cajon Valley. It should be possible to secure enough water from wells in Mission Valley to irrigate all the land there. It is estimated that ultimately over 15,000 acres will be irrigated from San Diego River. This district has been comparatively free from litigation, there having been only a few minor court cases.

SWEETWATER VALLEY AND CHULA VISTA MESA.

Sweetwater River is south of San Diego River and flows into San Diego Bay south of National City. It rises east of Cuyamaca Peak and passes through mountains for 30 miles, after which it reaches more open country. Sweetwater dam is constructed across a gorge where the river passes through San Diego County almost parallel to the coast. The principal valley is known as Sweetwater Valley and is located below the reservoir. The Chula Vista mesa, with its lemon groves, borders

[1]U. S. Geol. Survey, Water Supply Paper No. 300.

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San Diego Bay on the south side of the river. A number of small valleys of less importance are located along the river in the mountains, among them being Lawson Valley and the basin about Descanso.

Sweetwater Valley and Chula Vista contain 14,080 acres of tillable land and 4,750 acres are irrigated. All of the water is secured through the Sweetwater system excepting a little pumped from wells. The crops grown include lemons, oranges, grape fruit, olives, alfalfa, grain, and vegetables, all being irrigated excepting grain and in some cases olives. Land holdings are small.

The soils are generally light sandy loams with some river sediment in Sweetwater Valley. In some places the citrus groves extend well up on the hill slopes, water being pumped from wells in Sweetwater Valley for their irrigation. Some heavy soil is found on the Chula Vista mesa or National ranch lands and a hardpan is present which is blasted for the planting of citrus trees.

One acre-foot per acre annually is considered ample for citrus orchards but the amount of water stored in Sweetwater reservoir has not always been sufficient for the delivery of this amount and the actual use has fallen as low as .3 acre-foot per acre.

The irrigation system is owned by the Sweetwater Water Company, formerly known as the San Diego Land and Town Company, which is a corporation supplying water to the land owners. The rate is $7 per acre per annum up to a total of 350,000 gallons. A charge of 2 cents per thousand gallons is made for any amount in excess of this. The distributing system is of iron pipe and the water is measured to land owners through meters of the type used for city domestic systems. The company claims all flood waters of Sweetwater River. The company or its predecessors have been involved in a number of very expensive lawsuits.

Sweetwater reservoir has been enlarged twice since its original construction, the last addition to the dam being completed in 1911, when the height was raised 15 feet. The present capacity is 35,422 acre-feet. The total cost of the system is over one million dollars. The dam is curved and originally was constructed of cement masonry but the last addition consisting of both height and thickness was of concrete. The height now is 113 feet. The watershed above the reservoir is 186 square miles in which the elevations range from 200 to 6,000 feet above sea level. The rainfall at the dam is about 12 inches and the average for the entire shed is estimated at 20 to 21 inches. The average evaporation from Sweetwater reservoir amounts to 4½ feet in depth annually. The mean annual run-off of Sweetwater River for eighteen years is 10,700 acre-feet. The capacity of the reservoir before the last enlargement was 22,500 acre-feet. This capacity was not sufficient to store all of the floods in a year of high rainfall and at times water over-topped the dam. The present capacity is sufficient for impounding the entire run-off of the watershed except possibly in an extremely wet year and the enlargement

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greatly increases the efficiency of the Sweetwater system. The discharg of the river in only one of 18 years exceeded the present capacity of th reservoir. Some years scarcely any water has been stored in the reser voir but it is safe to have storage capacity for a 3-year supply. Durin the dry years of 1898 to 1900 twelve pumping plants were installe along Sweetwater River to supplement the supply in the reservoir. Th plants have an aggregate capacity of 794 miner's inches. They hav not been operated for several years. It is probable that the additio to the dam will result in a slight increase in acreage irrigated but thi improvement is regarded as one of security rather than extension o the company's service. Some increase may come from the operation o pumping plants now located along the river and from further develop ment of underground waters. There being no diversions below Sweet water dam pumping should not lead to trouble and the undergroun supply appears to be good.

A reservoir site is located on Sweetwater River near Descanso a an elevation of 3,300 feet and 24 miles above the Sweetwater reservoi A survey of this site shows that a dam 100 feet high would provid storage capacity for 10,000 acre-feet. Since Sweetwater reservoir no has sufficient capacity to store all run-off of the river in an ordinar year it is doubtful if the upper site will be utilized at least for a goo many years. The utilization of the upper site might permit powe development not possible from the Sweetwater reservoir and it migh also result in the prevention of some loss of water that now occurs fro the channel above Sweetwater reservoir.

OTAY AND TIA JUANA VALLEYS.

Otay and Tia Juana valleys, together with the adjoining mesas contain 36,318 acres of agricultural land of which 1,360 acres ar irrigated. Practically all of the water furnished by the mountai portions of these streams in the United States is claimed by the South ern California Mountain Water Company for the domestic use o San Diego. Otay Creek is the next stream south of Sweetwater River The Tia Juana rises in the mountains of Baja California but crosse the international boundary line and empties into the ocean south o San Diego Bay. Cottonwood Creek is the chief American tributary The main areas of agricultural land bordering the Otay and the Ti Juana are near the coast, where their valleys join and all of the irrigate land is located in this section. The Tia Juana has some valley i Mexico.

A number of small basins in the mountains do not contain much agri cultural land. The chief one on Otay Creek is Jamul Valley, while Pin Valley is the most important in the Tia Juana drainage. Pine Creek enters Cottonwood Creek from the north and is one of the main branche of this system as regards water supply.

The soils of these valleys are sandy loams, while reddish sandy and clay loams are found on the mesas. Some of the upper areas have

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hardpan at a depth of several feet below the surface, which must be broken up for tree planting, but after it has been broken no serious results have been experienced. Alkali is found only in small areas near the coast. The land bordering the streams is adapted to alfalfa and garden products, while the rolling mesa land is well suited to citrus and other fruit trees. Grain is grown where no water has been provided for irrigation.

Water for irrigation is supplied chiefly by pumping plants located in the valleys and it is used very economically. One miner's inch is sufficient for 10 acres of citrus fruits and for 5 or 6 acres of vegetables. The lands of the Little Landers corporation are located in Tia Juana Valley. Under this project it was intended that each member of the colony have 1 acre to farm aside from a building lot. The total tract comprises 500 acres, about 200 acres of which is already under irrigation. Water is derived from 5 wells about 30 feet deep, in which the water stands at 4 feet below the surface. The pumping lift is about 16 feet. Water is stored in small reservoirs and distributed through pipes. It is the intention for the water system to become the property of a mutual company of the land owners, but in 1910 the promoting company was temporarily, at least, financially unable to proceed with the original plan. The San Ysidro Irrigation District has been organized. It proposes a $75,000 bond issue for securing water from wells in Tia Juana Valley.

The system of the Southern California Mountain Water Company as planned will, when complete, include four storage reservoirs. The Upper and Lower Otay reservoirs were the first constructed. The third impounding basin has been formed by the completion of Moreno dam on the headwaters of Cottonwood Creek. There is a possibility that the fourth basin will be provided by the construction of a dam at the Barrett site just below the junction of Pine and Cottonwood creeks. The capacities of these reservoirs are as follows:

Capacities of reservoirs supplying water to San Diego.

Name.	Gallons.	Acre-feet.
Upper Otay	1,090,000,000	3,300
Lower Otay	13,000,000,000	39,900
Moreno	15,000,000,000	45,800
Totals	29,000,000,000	89,000
Barrett (proposed)	15,000,000,000	45,800

The Upper Otay dam is a curved dam of reinforced concrete 84 feet high on the west branch of Otay Creek and with a watershed of only 12 square miles. The run-off is not sufficient to fill the reservoir except when the rains are very heavy. The Lower Otay reservoir is on the main stream below the junction of Jamul and Dulzura creeks. It has a watershed of 100 square miles including that of the Upper Otay. The dam is 130 feet high and is a loose rock fill with a core of riveted steel plate protected on either side by a wall of concrete about 1 foot in

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thickness. The outlet is at the 48-foot contour, making only the upper 82 feet effective. The natural drainage is insufficient to fill the reservoir, but provision has been made for bringing water from Cottonwood Creek by the construction of the Dulzura conduit through the pass by that name, and the excess capacity of the Lower Otay may be used to store water that can not be held in reservoirs on the Cottonwood. The Dulzura conduit is 13.38 miles long and diverts water from Cottonwood Creek at the Barrett dam site. After crossing the divide between the Cottonwood and Otay watersheds it discharges into Dulzura Creek, whose course the water follows en route to Lower Otay reservoir. The conduit has 9,219 feet of tunnel and 4,490 feet of flume, the remainder being open ditch lined with concrete. Moreno dam is constructed in a rocky gorge of the high mountains and is a rock-fill with an upper face of cement masonry covered with concrete slabs to make it water-tight. Underneath the superstructure is a concrete foundation reaching to bedrock. The height of the dam is 365 feet over all and 150 feet above the stream channel. Five and a half feet can be conveniently added with considerable increase in capacity. This dam is in volume one of the largest constructed and cost $750,000. The reservoir has a drainage area of 135 square miles. The Barrett site consists of a narrow gorge where it is possible to build a high dam without great length. Any water that cannot be stored in the Moreno reservoir can be passed on to a reservoir at Barrett site, and both are above the Dulzura conduit which connects the Cottonwood system with Otay Creek. The Barrett site has a watershed of 115 square miles, exclusive of that above Moreno dam. The mean annual discharge of Cottonwood Creek near Jamul, from 1905 to 1910, was 31,000 acre-feet.[1] Still another reservoir site, located in Pine Valley, has been reported, but there is no assurance that this will be utilized.

This system has been constructed primarily for serving the city of San Diego with a domestic supply and although construction has been a little in advance of the needs of the city contracts for the delivery of water for irrigation have not been made as it is anticipated that the city will soon acquire the system as a municipal plant. If all of the water were now conserved there would be more than is now needed for domestic use, but as the city is growing rapidly it is probable that the time will come when the entire supply will be required. There is a drop of 700 feet between the lower end of the Dulzura conduit and the Lower Otay basin which offers some possibilities for power development.

The Southern California Mountain Water Company acquired the rights of a number of companies, among them the Mount Tacate Land and Water Company, the Otay Water Company, and the Jamacha Irrigation District, which failed to materialize. Some increase in the irrigated land on the lower part of the two rivers should come from pumping, but this can not be great as the underground water will probably be diminished by storage in the mountains.

[1]U. S. Geol. Survey, Water Supply Paper No. 300.

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Summary for San Diego County.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
Santa Margarita River valleys and Fallbrook	114,072	1,632	10,000	Storage on Temecula Creek and underground waters.
San Luis Rey, Escondido, and Santa Ysabel valleys and Linda Vista	154,498	4,996	51,600	Storage on San Luis Rey, Escondido, and Santa Ysabel rivers and underground waters.
San Diego River valleys and mesas	44,700	7,143	15,000	Storage on San Diego River and tributaries and underground waters.
Sweetwater Valley and Chula Vista Mesa	14,080	4,750	7,500	Underground waters.
Otay and Tia Juana valleys	36,318	1,360	3,000	Storage on Cottonwood Creek and underground waters.
Totals	363,668	19,880	87,100	

COLORADO DESERT AND RIVER VALLEYS.

The country east of San Gorgonio Pass has conditions that differ in many respects from those within the coastal drainage of southern California, yet in other respects there are some characteristics in common. Agricultural development once begun on the desert has been as rapid as that near the coast. This section, on account of its long hot summers, is not the first choice of most home builders for residence, although it enjoys proximity to beach and mountains not found in many of the interior irrigated sections of the West, and it has grown rapidly in spite of disadvantages for residence.

The rainfall is of no value in supplying moisture to crops or as a water supply. Colorado River is the source of water for all irrigated districts excepting Coachella Valley. This stream depends principally on the snows in the mountain states. The incentive for economy in the use of water is not so great as it is near the coast.

Practically all of the land on the desert originally belonged to the Government. Consequently, land holdings are large compared to those on the west side of the range where settlement was by purchase of private lands. Ranching predominates, although many of the fruits grow as well as on the coast. This division has peculiar problems in the control of Colorado River and the rights to use water from an interstate and international and navigable stream, some not being within the jurisdiction of the State. The organizations for the distribution of water have not all taken their final form, but it is evident that they will eventually be managed by the water users themselves.

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COACHELLA VALLEY AND DESERT.

Coachella Valley and the desert is a northwestern extension of C
rado Desert and the valley is a portion of the Salton basin and is larg
below sea level. The upper portion of the desert is also a continuat
of San Gorgonio Pass. Both the valley and desert are within Rivers
County. The greater portion of Coachella Desert is not considered
an agricultural country as the winds which sweep through San Gorgo
Pass and toward the lower heated area are so severe that tender ve
tation can not withstand the drifting sand carried. The desert
crossed by rocky washes leading from the mountain canyons and
dotted with mammoth hummocks and covered with a sparse growth
greasewood and cactus in its upper areas. All brush leans towards
southeast, showing the prevailing trend of the air currents. Excepti
may be made regarding small pockets of land lying at the mouth
Palm Canyon on the southwest side and below Mission Creek Canyon
the northwestern end of the desert. About 10,000 acres near Pa
Springs and about 6,300 acres below Mission Canyon may be conside
as agricultural land. Morongo Valley is situated in the San Bernard
Mountains, a few miles north of the upper end of the desert, at an ele
tion of 2,300 feet above sea level. It is a mountain basin crossed by
and Little Morongo creeks, both of which drain southward to Coach
Desert. It lies in San Bernardino County and contains 8,300 acres
agricultural land in addition to the number of acres given for Pa
Springs and Mission Creek. Coachella Valley includes 142,600 acres
agricultural land, making a total of 167,200 acres for both desert
valley, including Morongo Pass. These sections are considered toget
because they have in large measure a common water supply.

Whitewater River is the principal stream and drains the eastern sl
of Mount San Gorgonio with an elevation of 11,485 feet. The ri
enters the desert at the northwestern end and its wash may be tra
practically all the way to Salton Sea. The Whitewater runs through
the entire year. East of the Whitewater is Mission Creek, big and Li
Morongo creeks, and other streams of less importance. These may
considered tributaries of the Whitewater as the water discharged fr
their canyons is absorbed by the gravels on the desert and must even
ally mingle with those of the larger stream before reaching Coach
Valley. The water from the main river itself seldom runs on
surface for more than a few miles after leaving the canyon.

The lands of the desert are made up of the alluvium from the mo
tain streams which enter from all sides. Palm Canyon and Tahqu
Creek drain the San Jacinto Mountains, but the eastern slope is
precipitous that the drainage is much less than that from the San B
nardino Mountains. The fall from San Jacinto Peak, with an elevat
of 10,805 feet, to Palm Springs, is over 9,000 feet in 7 miles.

The soils of Coachella Valley vary from the coarse sands of
alluvium of local streams in the upper areas to tight adobe originat
as Colorado River sediment in the lower areas near Salton Sea. All

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has been brought to the surface in the low areas by the underground water. Lands bordering Salton Sea contain salts in excess of 3 per cent.[1]

All of the land originally belonged to the Government, but the Southern Pacific Railroad Company, through its grant, acquired half of the sections in most of the valley and desert. For years the railroad lands were not on the market and settlement begun on the Government land under the desert and homestead acts, but within the last few years much of the railroad land has been sold. Farms range in size from 40 to 160 acres. Portions of the valley are reserved for the Indians.

According to the irrigation census taken in 1909, 3,791 acres were irrigated in Coachella Valley that year. There has been a slight increase since 1909. The irrigated land is scattered about Indio, Coachella, Thermal, and Mecca and some is on the Indian reservations. About 50 acres are irrigated near Palm Springs with water from Palm Canyon and Whitewater River. The figures are not available on the acreage irrigated in Morongo Valley, but it is probable that a small area of land is receiving water as the result of late development by wells.

The water for Coachella Valley is the underground supply which percolates southeastward from Whitewater Canyon toward the Salton basin. It is estimated that nearly 500 wells have been drilled in the valley. About 150 are pumped, and most of the others are artesian. The first wells were 400 or 500 feet in depth. The artesian area extends through the center of the valley above the Salton basin and at one time it reached beyond Indio covering an area of 140 square miles. The draft on the underground water was heavy and during the ten years ending in 1905 a shrinkage of one third in the area occurred, with the result that some of the wells in the upper portion of the valley near Indio which originally flowed had to be pumped. The artesian area is all below sea level, but this has no real significance, as it is impossible that underground water comes from the sea, since wells near the Salton basin produce saline water, while the wells in Coachella Valley deliver water with a high degree of purity.[2] Following heavy rains in 1905 the underground water partially recovered its former level and the discharge of many wells was restored to the former yield. Within the last few years some wells from 1,000 to 1,400 feet deep have been drilled and these produce a heavy artesian flow. They penetrate a lower water-bearing stratum in which the pressure is stronger. The gasoline engine is the most common power for pumping plants.

The crops of Coachella Valley include cantaloupes, grapes, Bermuda onions, cotton, citrus fruits, alfalfa, grain, and dates. All crops are watered as this is a section where nothing can be grown without irrigation. The climate resembles that of Yuma and Imperial Valley and the maximum daily summer temperatures range from 90° to 120° Fahrenheit. The summer season is seven or eight months in duration and the growing season extends almost throughout the entire year. Measurements of the amount of water used on different crops are not available,

[1] U. S. Dept. Agr., Bureau of Soils Survey of Indio Area, California.
[2] U. S. Geol. Survey, Water Supply Paper No. 225.

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but it is probable that alfalfa requires about 4 acre-feet per acre ar most other crops no more than half that much. Where flowing wel are depended on for irrigation it is customary to store the small di charge of wells in earthen reservoirs in order that a larger irrigatir head may be used from the supply thus accumulated.

The Rodgers ditch diverts water from Whitewater River and carries to Palm Springs, where it is sometimes sold to the Indians for use on t reservation. The ditch has a capacity of 350 miner's inches.

It is difficult to estimate the amount of water entering the gravels Coachella Desert from the mountain watersheds. The rainfall in t valley, as shown by records at Palm Springs and Indio, is approx mately 3 inches annually and it is probable that the evaporation is suf cient to offset all precipitation over the desert itself. Only the high mountain watersheds can be considered as contributing much to t underground water supply. The Whitewater has a mountain watersh of 60 square miles, Mission Creek 35 square miles, and Palm Canyon 1 square miles. The rainfall varies from 3 inches to 20 inches within the watersheds. As there is little timber or brush on the eastern exposur the run-off is rapid, but on the other hand the evaporation in this h dry climate is excessive. It is not probable that more than one tenth the agricultural land in Coachella Valley will ever be irrigated from i own watershed and underground water.

The water users of Coachella Valley have brought suit to restrain t Consolidated Reservoir and Power Company from diverting water fro Whitewater Canyon to be used for the development of electric pow and irrigation in San Gorgonio Pass.

IMPERIAL VALLEY.

Imperial Valley is the reclaimed portion of the Colorado Desert. T region was uninhabitable before irrigation began in 1900. Develo ment since has been very rapid.

Imperial County was formed from San Diego County in 1907, it th having the required population of 10,000. The county now suppor five incorporated cities of 1,000 to 2,000 population, viz., El Centro, t county seat, Imperial, Brawley, Calexico, and Holtville; also sever other growing settlements.

The Salton Basin was once part of the Gulf of California and t land of the valley was formed as delta of Colorado River. Nearly of the irrigated section is below sea level, the bottom of Salton S being more than 280 feet below sea level.

The soil is silt several hundred feet deep and varying in hardness different parts of the valley and at different depths, but the textu remains fine whether the consistency is that of adobe or of the loo soil. The soils at the edges of the basin are slightly coarser, due to t intermingling of sand from the mountain washes. In general, t central portion of the valley contains more hard soil than the surroun ing portion. The hard soil, while containing a greater degree of fertili than the loose soil, is more difficult to pulverize by cultivation and mu

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be worked at just the right time after applying moisture. The difficulty in irrigating the soil is to get moisture to sufficient depth that it may be retained and not lost by evaporation in the hot and drying atmosphere. The loose soil takes water much more freely and retains it for a greater length of time, consequently it is not necessary to irrigate so frequently as with hard soil. The desert soils are rich in salts and minerals, but deficient in humus and nitrogen. Alkali is present in proportions that are damaging to plant life in limited areas only. Some of these areas, such as that near Mesquite Lake between Brawley and Imperial, have been in part reclaimed by washing the land. The problem with alkali is one of the proper handling of water in irrigating. If water is used in excess, a local ground-water table will be formed, the rise of which will bring the salts to the surface. If the irrigation is carefully done and only enough water applied to furnish the required amount of moisture for plant growth, trouble need not be expected. Where the alkali content is high and water is applied in furrows, it is necessary to keep the salts well distributed by an occasional flooding for the growing of such crops as asparagus. The land slopes from 2 to 15 feet per mile, depending on location.

This region is known for the long, hot summers. The climate and soil are conducive to luxuriant plant life where the necessary amount of moisture is supplied. The maximum daily temperatures of summer range from 90 to 126 degrees Fahrenheit. It seldom falls below freezing in winter, although temperatures of about 20 degrees are recorded. The relative humidity is low during most of the hot season. The rainfall is not of value in supplying moisture to crops. Records for the valley cover a comparatively short period only, but a 31-year record at Indio in Coachella Valley, where conditions are about the same, shows an annual precipitation of 2.70 inches. The prevailing winds are from the southwest. They become dust storms at times preceding the hot weather, but are refreshing in summer.

A great variety of crops can be grown. The California Experiment Station is experimenting to determine the best standard crops. It has been demonstrated by land owners that the following are adapted to the soil and climate: Alfalfa, barley, Kafir and Egyptian corn, cotton, sugar beets, cantaloupes, watermelons, Bermuda onions, tomatoes, cabbage, sweet potatoes, chili pepper, blackberries, grapes, apricots, figs, olives, and dates. Some of the foregoing are limited to certain parts of the valley and to certain kinds of soils. The medium and soft soils have a greater range of suitable crops than the hard soils. Some of the crops, including alfalfa, are adapted to all of the classes of soils, although alfalfa thrives best in the softer grades.

Frost excludes citrus fruits from the selection of crops for the lowest areas. Vegetables, such as tomatoes, have been successfully grown in winter. Crops that have been grown with varying results in different cases and regarding which conclusions can not yet be drawn are: Potatoes, wheat, Indian corn, peaches, pears, plums, and strawberries. Apples and cherries are not suited to the hot desert climate.

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The chief industries include the growing of alfalfa, grain, cotton melons, grapes, and asparagus; also cattle, sheep, and hogs. Dairying is also followed with great success. Alfalfa constitutes a large portion of the feed for live stock, the greater number of the fields being pastured and not cut for hay. Alfalfa produces seven and eight crops per year.

Underground water in amount for extensive irrigation is not found in Imperial Valley. Borings at Imperial and El Centro reached depths of 800 to 1,500 feet without striking water. Wells bored to a depth of 800 to 1,400 feet at Holtville and north of Holtville flow. The water produced has a temperature of about 102 degrees. The surface of the ground in this locality is near sea level. The water probably percolates from Colorado River. The flow of wells is light and sufficient only for the irrigation of tracts of a few acres and for domestic use. An artesian flow was secured at Brawley from a well 1,880 feet deep.

Imperial Valley is irrigated from Colorado River by a canal constructed by the California Development Company. When the canal is clean, it has a capacity of over 3,000 second feet. The water is directed from the river just above the international boundary line. On account of the topography of the country, the canal detours into Mexico before entering Imperial Valley. It was necessary to organize a separate company, La Sociedad de Irrigacion y Terrenos de la Baja California under the laws of Mexico, to operate the portion of the system in that country, but the stock of the Mexican company was owned by the California Development Company. The main canal is 56 miles long. It then divides near Sharpes, just south of the international boundary into three branches, one each for the eastern, central, and western portions of the valley. The headgate near Colorado River is a concrete structure. Originally the drops, gates, and other structures along the main canal and its branches were of wood, but these are gradually being replaced by concrete structures of the best type.

The lands of Imperial Valley all belonged to the Government except the alternate sections of railroad land adjacent to the Southern Pacific track at the northern end. Some land was taken by settlers under the Homestead Act, but the major portion was filed on under the Desert Act; consequently there are many holdings of 320 acres each and families sometimes control one or two sections. Up to the present time there has not been much subdivision and the average size of farms is over 160 acres. The California-Mexican Land and Cattle Company owns several thousand acres near Calexico, also nearly a million acres south of the international boundary, all operated as one ranch from American headquarters.

The California Development Company delivers water at fixed rates to mutual companies that were organized by the settlers of the various districts laid out according to topographical features of the valley. The Development Company constructed the distributing systems and transferred them to the mutual companies in exchange for their capital stock. The Development Company then sold the stock of the mutual companies to the settlers. The price of the stock steadily advanced

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with the demand from $5.75 to $25.00 per acre. The cost of constructing the distributing systems was much less, so that the Development Company profited by this transaction aside from any profit from the sale of water.

Contracts were also made with the mutual companies for the delivery of water at the rate of 50 cents per acre-foot, the amount to be delivered not to exceed 4 acre-feet per acre annually. The water charge was in turn paid by the user to the mutual company of which he was a member. The Development Company stands a loss by seepage and evaporation of 10 per cent of the amount delivered. Any loss in excess of this amount must be stood by the mutual companies. In addition to the water charge, mutual company members must pay the cost of maintenance and operation of their distributing system and the stock is assessed at the rate of about $1.25 per year for this purpose. The delivery of water is the main expense of operation and the cleaning of canals is the chief item in maintenance. The waters of the Colorado are heavily laden with silt and the quantity entering the ditches of the mutual companies exceeds 1 per cent by volume after settling thirty days, as shown by extended measurements of this office. This represents the quantity of mud that must be removed each year. Various types of dredges are operated to keep the channels open and crews of brush cutters are kept at work clearing the banks of weeds and the channels of aquatic growth.

Water is delivered to the user on order, within reasonable limitations. The duty of water, under Imperial Water Company No. 1, is 1.75 acre-feet per acre. Nearly one half of the land in this district is in alfalfa. The duty in the other mutual company districts is a little lower, but the No. 1 district being the oldest, shows more correctly the amount of water that will be used in the future. Alfalfa requires about 3 acre-feet when producing seven to eight crops. All other crops require no more than half as much. Water is measured to users as the basis of computing the charges.

Imperial Water Company No. 5 has an excellent drainage system in connection with its irrigation system. Provision has not been made in the other districts for drainage. Conditions for natural drainage from the land are improved by the erosion of the deep channels of New and Alamo rivers by the Colorado floods of 1905 and 1906.

Colorado River is an interstate and international stream and a division of the water between the two nations is subject to treaty. The river is classed as navigable by the Government and matters of navigation are controlled by the War Department. Questions arising from the use of water for irrigation in the several states embraced in its drainage would be referred to the Federal courts. Questions relating to the use of water within California are under the jurisdiction of the State courts. As yet troubles have not arisen between appropriators within the State. The California Development Company filed on 10,000 miner's inches from the river in the manner prescribed by the State. The company also secured concessions from Mexico for the taking of

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water from the river in that country, and it is under obligation deliver one half of the total amount diverted for use on Mexican lan provided the land owners offer the rate charged in the United Stat Mexican landowners have not taken full advantage of this opportuni Some land south of the international boundary is irrigated from main canal, but it is in American ownership. The right to water use in Imperial Valley is based on use, whether the right be vested the user or the public service company. The first use in the val antedates the diversions for other valleys on the lower river, except th of the old private ditches at Yuma and Palo Verde.

Litigation in Imperial Valley has related principally to various co tracts between the development and mutual companies, to stock own ship, and to the legality of the development company's charging wh is equivalent to a bonus, while at the same time charging for water. has been demonstrated under the receivership of the development co pany that the water charge is sufficient to pay a good profit withc other sources of revenue. The rate has not been fixed by the Coun Supervisors or by the State Railroad Commission. In *Thayer* vs. *Ca fornia Development Company* it was decided that the company mu deliver water to persons having access to its canal and offering the usu charge when demanded for use on land within the district origina intended to be supplied, provided the water was available and t company was already equipped for such delivery.[1]

Electrical power is developed at Holtville, at the plant of the Holt Power Company, with water from the canal system. The water turned into Alamo River and most of it is used or will be used f irrigation by the North End and other mutual water companies th have filed on the waste waters.

The California Development Company is at present heavily in de and under the management of a receiver. The Mexican company is a in the hands of a depositario or Mexican receiver. The events whi led up to the company's insolvency are matters of history and rela largely to the expense of controlling Colorado River. The large creditor is the Southern Pacific Company, which advanced money f turning the river to its original channel to prevent inundation Imperial Valley and its own property by the rise of Salton Sea. T Southern Pacific Company took as security for loans the control of t Development Company. The Imperial Valley Irrigation District h been organized under the State law to include 511,000 acres and all the land now irrigated, and this organization is now bargaining wi the Southern Pacific Company with the view to acquiring the ma canal system, the presumption being that the railroad company will b the system at receiver's sale to protect its own claim, after which it w be in position to dispose of the property to the water users. It is t plan of the irrigation district to take the place of the California Dev

[1]Since this was written the Supreme Court of California reversed the decision of t lower court and decided that the California Development Company is not a pub utility.

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opment Company and deliver water to the mutual companies as they now stand; also to other lands within the district and outside of the territory covered by the mutual companies.

Meanwhile irrigation under the present system is being extended by the construction of a canal to skirt the east side mesa. In view of the experience already gained, a duty of 1 cubic foot per second for 182 acres is being taken as the basis in designing this extension. The following table shows the extent of irrigation at present under the system of the California Development Company:

Summary of irrigated areas under California Development Company, 1912.

Name of company.	Area irrigated. Acres.
Imperial Water Company No. 1	99,600
Imperial Water Company No. 4	18,000
Imperial Water Company No. 5	45,000
Imperial Water Company No. 6	15,000
Imperial Water Company No. 7	16,000
Imperial Water Company No. 8	24,000
Imperial Water Company No. 12	11,000
Total	228,600

The Imperial South Side Water Company was recently formed from the district of Imperial Water Company No. 1, and is adding 13,000 acres to the area irrigated. This, together with a new allotment of stock now permitted in Imperial Water Company No. 1 on the basis of four instead of five shares to 5 acres, makes it possible to irrigate nearly all of the 135,000 acres that were originally in the No. 1 district. The Imperial South Side Water Company, also the Imperial East Side Water Company, and the South Alamo Water Company, are now purchasing water directly from the depositario of the Mexican company. The East Side and Alamo companies serve small areas. The North End Water Company filed on the waste waters of Alamo River and diverts them for use on lands near Salton Sea. The district embraces 10,000 acres and 6,360 acres are irrigated. The Imperial North Side Water Company has been organized for an additional area to receive water through the canal of the North End Water Company. The Bernice Water Company has a district of 30,000 acres to be irrigated north of District No. 5. Approximately 260,000 acres are now irrigated in the valley, the area being the largest under a canal in the United States. The new East Side canal, together with the projected Bernice dam, will add 131,000 acres to the irrigated area. An attempt is being made to place water on about 5,000 acres above the West Side canal and north of Signal Mountain, but it may be difficult to maintain a ditch for this section, owing to shifting sand dunes. About 400,000 acres will eventually be irrigated in the valley. With appropriations from the river from Yuma and Palo Verde, together with an increasing demand for water in Mexico, it is doubtful if water for a greater acreage could be safely depended on unless the discharge of the river is regulated by

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storage reservoirs in the mountains. The river has a drainage area of 225,000 square miles. The mean annual discharge at Yuma for the period 1902 to 1910 was 16,300,000 acre-feet.[1] The governing factor is the discharge in the several seasons with reference to the use of water at the same time. The maximum use of water is in August and, fortunately, it nearly coincides with the flood season for the river. The river is lowest in January and February. The annual flood comes in May, June, and July, and almost without variation the highest water occurs in the latter part of June. The discharge of the river varies from extremes of 3,500 to 150,000 second feet.

The valley contains 510,000 acres of irrigable land. About 129,000 acres on the east side mesa and 177,000 above the canal on the west side are classed as irrigable, making a total of 816,000 acres, of which only 400,000 are certain to be irrigated. Soils on both the mesa and the west side are slightly coarser than those of the basin. Water could be pumped for the irrigation of some of the land above the canals, providing the supply in the river is sufficient. The western territory includes the valleys of San Felipe and Cariso creeks. It is possible that a limited area west of Salton Sea and north of Superstition Mountain may be irrigated from wells, as this section gives promise of some underground water.

YUMA INDIAN RESERVATION.

The Yuma Indian Reservation embraces that part of Yuma Valley in California. It is opposite the town of Yuma, on the Colorado River, and reaches from Pot Holes to El Rio, being in Imperial County. The altitude at Yuma is about 100 feet. The Indian Reservation is included in the lands to be watered from the Yuma Government Project. Construction is done by the Reclamation Service of the Interior Department in accordance with the reclamation act. The irrigation system is being paid for by and will become the property of the land owners who have formed the Yuma Valley Water Users Association.

Conditions at Yuma are best described by comparison with those at Imperial, there being much similarity in soil and climate. The soils of the reservation are sand and silt loams and adobe. They contain more sand and are a little coarser in texture than Imperial Valley soils. In general they are probably less fertile, but are easier to keep in a mulched condition by cultivation. The soils originated as Colorado River sediment. Limited areas on the reservation contain from 1 per cent to 3 cent of alkali, but the greater part of the land has less than .2 per cent.

The temperatures in both summer and winter are generally 2 or 3 degrees lower than in Imperial Valley. The humidity is about the same except for the latter part of summer, when it is slightly greater at Yuma owing to the winds which blow northward along the river channel from the Gulf of California during this season. The prevailing winds are from the west and southwest. Dust storms are frequent in the spring

[1] U. S. Geol. Survey, Water Supply Paper No. 300.
[2] U. S. Dept. Agr., Bureau of Soils, Soil Survey of Yuma Area, Arizona.

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The normal annual rainfall is not over 3 inches and the evaporation from a water surface amounts to about 7 feet in one year.

The eastern half of the reservation was open to entry when water for irrigation was available from Laguna Dam. The farm unit is 40 acres. Several sloughs traverse the valley near the river and portions of the land were formerly overflowed when the river was in flood. Levees have now been constructed as a part of the irrigation project to protect the lands from overflow. The moist areas support a rank growth of brush, which is expensive to clear, but the productiveness of the land under irrigation justifies the cost.

The western portion of the reservation is still held for the Indians, there being about 700 families, each with a 10-acre allotment. The area irrigated in 1912 is 6,500 acres.

All crops are irrigated. Alfalfa is the principal crop, although both southern and Egyptian cotton, melons, vegetables, berries, etc., are grown with success. Apricots, figs, and olives may be produced and live stock and dairying will no doubt be developed. Frosts are too severe on the river bottom lands for citrus fruits. They are grown on the Yuma mesa in Arizona, which is 60 or 70 feet higher than the valley. Alfalfa is flooded by the border method and vegetables are irrigated by furrows. The duty of water under the Yuma Project is five and one half acre-feet per acre per year. Alfalfa produces seven crops.

Water rights on Colorado River have not been adjudicated. Several small private ditches on the Arizona side received water intermittently prior to the construction of the large canals on the lower Colorado. They received water only at high river stage and irrigation under them was irregular. It is the intention of the water users in the several valleys on the lower Colorado to oppose contemplated diversions in other States near the river's headwaters.

The Yuma Project was designed for the irrigation of about 111,500 acres, of which 75 per cent was private land. Of the total, 16,500 acres are in California and 95,000 acres are in Arizona. Of the land in Arizona, 15,000 acres are in Gila Valley above Yuma; 50,000 acres are in the Colorado River Valley below Yuma, and 30,000 acres are on Yuma mesa and must be supplied by pumping from the canal under a total head of about 80 feet. The project was 73 per cent complete in June, 1912. Laguna Dam is a diversion weir across the river, 15 miles above Yuma. It raises the level of the river 10 feet and is 4,780 feet long. It is a loose rock fill between parallel walls of concrete, and has a covering of concrete. The dam was not intended to form a storage reservoir and the small basin above the dam rapidly filled with silt, except in the river channel. A canal is taken from the dam on the Arizona side for the lands in Gila Valley. A larger canal leads from the dam to Yuma on the California side, and laterals from this canal supply the Indian reservation with water. The main canal crosses under Colorado River at Yuma by a concrete inverted siphon and covers the valley land in Arizona below Yuma by gravity. Laguna Dam cost about $2,000,000,

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and, together with the levees for the protection of the valley on both sides of the river, accounts for the high acre cost of the project. The cost of water rights, when paid for in ten equal annual installments as originally provided for under the reclamation act, has been fixed at $55 per acre. So many of the settlers were unable to make the second annual payment that a sliding scale of payment was permitted, but the total cost under this was raised to $66 per acre. The annual payments are: First, $5.50; second, $1; third, $2; fourth, $3.50; fifth, $5; sixth, $7; seventh, $9; eighth, $10; ninth, $11; and tenth, $12 per acre.

In addition to the regular payments, a charge of $10 per acre was made for the lands on the Indian reservation, to be paid at the rate of $1 per acre per year. The annual charge for maintenance and operation has been fixed at $1 per acre and it will be adjusted from time to time in accordance with the needs for funds.

The town of Bard originated with settlement of the reservation. Underground water is abundant for domestic use and can be secured from wells not over 30 feet in depth.

PALO VERDE VALLEY.

Palo Verde Valley is situated on Colorado River and is chiefly in Riverside County, but the southern end reaches into Imperial County. It is 275 feet below sea level. The valley is limited on the west by the abrupt change in level to the mesa. Soils and climate are much like those of Yuma and Imperial Valley, the resemblance being a little closer to Yuma. The soil is Colorado River silt mixed with sand. The combination is one of fertility and good porosity. The long hot summers stimulate the growth of plants and a great variety of crops thrive when supplied with moisture. The annual rainfall is less than 3 inches and of no value to crops. Alfalfa, grain, and cotton are now the principal crops of this newly irrigated section.

The principal towns are Blythe and Palo Verde, but settlements have been started at Neighbors and Rannels. This region is not yet reached by railroad. Blythe is reached by stage from Glamis on the Southern Pacific, distant 60 miles, and from the Santa Fé near Parker, 36 miles away.

The irrigation system was begun for the Blythe ranch when it was in individual ownership. This property of 40,000 acres was later acquired by the Palo Verde Land and Water Company, which continued the construction of the canal system. The company proposes to extend the system for the reclamation of 60,000 acres of land in addition to the Blythe lands. The organization of the Palo Verde Mutual Company was caused and the existing ditches and water rights of the land and water company were exchanged for 60 per cent of the mutual company's stock. The mutual company must complete the irrigation system for the entire 100,000 acres. The mutual company stock is issued to purchasers of Blythe ranch lands or is sold to settlers on the other lands, by the land company. Shares have a par value of $10, there being one share per acre. The stock is assessed for maintenance and

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operation at the rate of $2 per acre per year. The number of shares issued is 2,500. A share represents the right to the one hundred thousandth part of the water in the canal and the stock is appurtenant to the land. Water has not been measured and the duty of water under the system is not known.

Water rights are based on riparian land as well as appropriation and use, inasmuch as the 40,000-acre tract has a 17-mile frontage on the river. Farms average about 80 acres.

The headgate of the Palo Verde canal was constructed in a rock cut at Black Point. The river at the intake is unusually wide and the fluctuation in the water level is about 7 feet. The canal is on a grade of .02 per cent and has a capacity of 35 second feet. The canal first leads to Olive Lake, 5 acres in area, which is utilized for a settling basin. The distributing system branches out below the lake. The system was capable of irrigating 20,000 acres in 1909. Extensions have been made since and will continue to be made as the lands are settled. Some of the lowlands subject to overflow from the river are protected by a levee. Questions arose recently regarding the character of some of the overflowed land. Claims were made that it should be State property, but the Government decided it was only subject to periodic overflow and was Government land open to entry. The lands in question embraced about 90,000 acres, much of which had been filed upon.

Underground water is abundant at depths of 10 to 20 feet. The water is excellent for domestic use and pumping for irrigation is possible.

The area irrigated in 1912 is 9,000 acres. The valley contains 85,000 acres of irrigable land, all of which will be irrigated.

CHUCKAWALLA VALLEY AND PALO VERDE MESA.

Palo Verde Mesa consists of two benches, the first rising about 40 feet above the valley and the second 10 or 15 feet above the first. Chuckawalla Valley is farther inland and is connected to the mesa through a gap between the mountains. The two sections have much resemblance in their conditions. The soils are little more sandy and less loamy than the land of Palo Verde Valley. The soil is adapted to the culture of fruits, as it takes water very freely, has natural drainage, is fertile, and can be kept in the good mechanical condition required for orchards.

Chuckawalla Valley is almost surrounded by mountain ranges and is well protected. Springs flow at several points at the rim of this basin and water is procured for domestic use from dug wells 30 feet in depth in places and may be secured at less than 200 feet in any part of the basin. A well was bored to a depth of 1,029 feet in the hope of securing artesian water. The water rose near to the surface, but did not flow. Boring to a greater depth would possibly give artesian water.

Water may be had in abundance from wells on Palo Verde Mesa about 130 feet in depth.

Chuckawalla Valley is from 300 to 500 feet in elevation. Some dry lake beds or areas with poor drainage are found in the low part of the basin.

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The best lands are above on the slopes. The land of both valley and mesa is free from alkali in harmful quantities and is covered with a growth of greasewood, sage brush, and cactus. Certain areas of Chuckawalla Valley support ironwood trees.

The first proposal to irrigate Chuckawalla Valley and Palo Verde Mesa was by the Chuckawalla Development Company. Extended surveys were made for bringing water from Colorado River. It was proposed to construct a storage reservoir at Bulls Head, 12 miles above Fort Mojave, by placing a dam across the river channel. Electrical power was to be developed by water from this reservoir and transmitted to pumping stations on a canal to take water from the river 20 miles above Ehrenberg, Arizona, the pumping being necessary to elevate the water to the mesa and Chuckawalla Valley. The project was for 200,000 or more acres of land in valley and on mesa. The project has been abandoned on account of the difficulty of securing a suitable foundation for a dam at Bulls Head and the cost of the work.

All of the land belonged to the Government and on the strength of the preliminary work of the development company nearly 300,000 acres of land was soon filed upon. The entrymen have now formed an association for the purpose of making their own investigations with a view to procuring water for irrigation. They propose to form an irrigation district and issue bonds to the amount of $6,500,000 for the construction of a canal system for 220,000 acres. The canal is to be filled by pumping from Colorado River, near Ehrenburg.

The irrigation district plan is not so well adapted to the reclamation of a desert as to the acquisition of a system which has been already financed, for the reason that the desert land has so little taxable value before water is applied. The disposal of the bonds may be a difficult matter.

Chuckawalla Valley has 246,000 acres and Palo Verde Mesa 106,000 acres of agricultural land. With pumping from wells on the mesa 250,000 acres or a greater area may eventually be reclaimed, provided no trouble is experienced in securing right to water from the river.

OTHER COLORADO RIVER LANDS.

Three other areas bordering Colorado River seem worthy of consideration as agricultural lands. The first above Palo Verde Valley is the tract bordering the river at Calzona in Riverside and San Bernardino counties. It has an area of 18,425 acres. The soil is similar to that of Palo Verde Mesa, but the slope to the land is not so even as that on the Palo Verde Mesa. The climate is much like that of Palo Verde. Many desert filings have been made in the past and some have been abandoned. Underground water is not counted on for irrigation. The promoters of Calzona are preparing to pump water from Colorado River for the town and for irrigation of 6,000 acres. Calzona is on the Parker line of the Santa Fé Railroad and is a trading point for mines in the surrounding mountains and for the Colorado River Indian Reservation.

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The next area going northward is Chemehuevis Valley. It is on Colorado River in San Bernardino County, about midway between Needles and Parker, and contains 5,060 acres. No development has taken place. The soil is river silt, but prospects for irrigation in the near future are not encouraging, as the nearest railroad is 25 miles distant. Little is known of the underground waters, but it is probable that the supply would be good on this tract adjacent to Colorado River.

A strip of valley and mesa land borders the Colorado northward from Needles and is a part of Mojave Valley, of which the greater portion is in Arizona. The valley also extends below Needles, but this is not classed as agricultural, as it is subject to overflow by the river. Valley lands near Needles are also endangered in the flood season, and in recent years the river has been cutting toward the west. More levees are needed for protection from floods. This area contains 89,065 acres, of which a few small tracts are irrigated and producing alfalfa. Some of the land is broken and washed and its classification is doubtful.

The valley supports willow and other brush. Underground water is plentiful at a depth of 20 feet.

Summary for Colorado Desert.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
Coachella Valley and desert	167,200	4,000	10,000	Underground waters.
Imperial Valley	816,000	260,000	400,000	Colorado River, San Felipe and Carisco creeks.
Yuma Indian Reservation	18,000	6,500	16,500	Colorado River.
Palo Verde Valley	85,000	9,000	85,000	Colorado River.
Chuckawalla Valley and Palo Verde Mesa	352,000	----------	250,000	Colorado River and underground waters.
Other Colorado River valleys	112,550	100	5,000	Underground waters of Colorado River.
Totals	1,550,750	279,600	766,500	

MOJAVE DESERT.

Mojave Desert, unlike Colorado Desert, can not depend upon a large river for water for irrigation. Although the largest of the divisions, it has been the least exploited and developed and it has the least prospect of becoming a highly productive country. Aside from a small portion adjacent to Mojave River, lands on this desert must be reclaimed principally by development of underground waters. It is impossible to even approximately estimate the amount of such waters available, as the usual methods of determination are very unreliable in a country with so little rain and such rapid evaporation of moisture from the heated sands.

The proper classification of the lands is difficult and at best is only a rough approximation. Where it is certain that water is available, the alkalinity of land is in some cases undetermined. It has been impossible to examine all of the areas personally within the time allotted for the

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investigation and it has been necessary to rely upon information from other sources.

The idea that this desert is one vast plain of heated sand and alkali flats, without water either above or below the surface. is erroneous. Although a territory of great extent, it is broken by hills, buttes, and mountains of no mean elevation and is dotted by innumerable depressions or so-called dry lakes, where surface waters accumulate and sink after showers and in which springs burst forth to make oases. Only the more important areas are included.

Development on the desert has recently been stimulated by the discovery that underground waters could be secured at reasonable depths in many of the sinks, and by the demonstration of the fact that apples and other deciduous fruits could be produced in the Southwest at elevations of 2,000 to 4,000 feet of a quality to compete successfully with those of northern states.

MOJAVE RIVER VALLEY AND ADJACENT MESAS.

This area includes the valley and desert sink of Mojave River, together with the mesa lands on both the east and west, at the northern base of San Bernardino and San Gabriel mountains. The valley of Mojave River should not be confused with Mojave Valley on Colorado River, near Fort Mojave. The bench immediately east of the valley opposite Hesperia is known as Apple Valley, although in reality it is a mesa. Farther to the east is the Box Springs country. The elevation of the entire strip of mesa on both east and west sides of the river is about 3,000 feet. Frosts are too severe for citrus fruits, but apples, pears, cherries, apricots, alfalfa, and vegetables are grown. The mesa lands have a uniform slope and are well suited to irrigation. The desert in its native state is covered with a growth of giant yucca, greasewood, or creosote bush and other brush. The expense of clearing land is not high.

Mojave River lands are adapted to alfalfa. The normal discharge of the stream is absorbed below the canyon, but the water is brought to the surface above Victorville Narrows. The water appears and disappears alternately along the river course, but the surface flow gradually diminishes until completely lost at Cronese Sink on the desert.

The areas of agricultural land are Mojave River Valley 195,000 acres; Mojave River Sink 40,000 acres; East Mesa 130,000 acres; West Mesa 545,000 acres. The area irrigated has not been very definitely determined, as the irrigated lands are scattered and a complete canvass could not be made, but it probable exceeds 10,000 acres.

The Hesperia Land and Water Company was originally organized for the sale of 3,000 acres and the irrigation of 30,000 acres of land. About 2,000 acres were sold. Water was sold to purchasers at fixed rates. The water was diverted from Mojave River and conveyed in pipes. The Hesperia Company has been succeeded by the Appleton Land, Water, and Power Company, which proposes to store water in

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the mountains for power development and for the extension of irrigation near Hesperia and the projected town of Appleton. A new main conduit consisting of 30-inch steel pipe is being laid. The operations of this company are being objected to by the Arrowhead Reservoir and Power Company and ranchers with lands riparian to the river.

A number of small ditches take water from the river for alfalfa irrigation from Hesperia to Cottonwood. Drafts are also made on the subterranean flow at various points. Works were constructed in the river bed near Daggett about 15 years ago for the collection of underground water by a subsurface flume.

The Mojave River Land and Water Company proposes to irrigate 20,000 acres by pumping along the lower river. Surveys have been made for the delivery of water to each 160 acres. Wells are being drilled and pumping plants installed at a rapid rate throughout the entire valley and adjoining mesa, the greatest activity being shown in the lower valley near Barstow, Daggett, and Otis, and in Apple Valley southeast of Victorville. Good wells are secured near Kramer and Hinckley west of Barstow. Wells several hundred feet deep near Barstow are reported to produce 150 miner's inches. Water can be had at shallow depths along the river near Daggett and Otis. A number of flowing wells are located just above the Victorville Narrows. The water stands at less than 10 feet from the surface in other wells and they produce 150 miner's inches on being pumped. Apple Valley has a good supply of underground water. Excellent wells are secured by boring about 500 feet in depth. The water must be lifted from 100 to 200 feet, depending on location. The borings show no rock and plenty of water bearing sand and gravel. A well at the Box Springs ranch gives a light flow and water may be had at less than 100 feet in other sections of the Box Springs country.

In general underground water is not so abundant on the west mesa. Water is reached at 30 to 200 feet, the depth being greatest toward the mountains on the south. Both dug and drilled wells have been made in this section. Ditches are being constructed to drain Cronese Lake in order that the lands of the basin may be farmed. Lands throughout the valley and mesa are being acquired under the Desert and Homestead acts with the expectation of growing alfalfa and deciduous fruits. The rainfall is about 8 inches. One miner's inch of water is sufficient for 2 or 3 acres of alfalfa and 5 to 10 acres of orchard, depending on the method of application.

The most important single work affecting this region is the project of the Arrowhead Reservoir and Power Company in San Bernardino Mountains. The Arrowhead dam is nearly completed and is located on Little Bear Creek, a tributary of Mojave River. The dam is of the hydraulic-fill type with concrete core wall and is one of the largest of its kind ever constructed. The drainage of several other tributaries besides Little Bear Creek is diverted into the reservoir through tunnels. The total drainage basin is 86 square miles. The capacity of the

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reservoir is 61,000 acre-feet. The company, after making measurements of rainfall and run-off at many points in the watershed and of loss by evaporation for a period of sixteen years, expects to deliver 40 second feet continuously from the reservoir. The water will be used first for power, and afterwards for irrigation. It is not known what lands will receive the water, but it will probably be used along Mojave River. The entire mountain watershed of Mojave River is 470,000 square miles. The summer discharge at Victorville is usually over 30 second feet. The mean annual discharge of the river from 1899 to 1905 was 69,400 acre-feet. A reservoir site is located above Victorville Narrows, but the depth to bedrock in the gorge has not been determined.

ANTELOPE VALLEY.

Antelope Valley is the southwestern part of Mojave Desert and is an undulating plain at an elevation of from 2,300 to 4,000 feet above sea level. It lies immediately north of the San Gabriel Mountains of the Sierra Madre Range and east of Tehachapi. Its northern and eastern limits are not so well defined but for the purpose of this report the division line between Antelope Valley and Mojave Desert is taken as the San Bernardino County line. It is possible that the line between the drainage of the two areas if known would include a small portion lying in San Bernardino County, but the major portion of the valley lies in the northeastern corner of Los Angeles County and the southeastern corner of Kern County. The valley is covered with a desert growth of sage, creosote, yucca, and other desert brush; also salt grass in some of the low areas. It has a maximum length of 60 miles and a width of from 20 to 3 miles. It contains 485,500 acres of agricultural land and of this amount 4,629 are irrigated. The land has a gradual fall from west to northeast at a rate of about 15 feet per mile until the eastern portion is reached. Here the surface is almost level. The plain is broken by Antelope, Rosemont, Lovejoy, and Black Buttes. The lower portion of the valley about Rosemont, Buckhorn, and Rodgers dry lake beds is an artesian area 240 square miles in extent.[1] Some salt is found in the lower areas but it is principally white alkali and it is believed that all of the land can be reclaimed. Land owners claim that two years of cultivation overcomes the damaging effect of the salts to such an extent that ordinary crops can be grown. This section is visited by winds and hummocks are formed about the desert brush in the central portion of the valley. Bench lands border the base of Tehachapi Mountains and the San Gabriels as far east as Palmdale. The benches are not visited by such heavy frosts as the lower areas and they are better suited to fruit growing. The lake beds sometimes contain water to a few inches in depth after storms and it is not certain that the lands occupied by them can be utilized for agriculture. The Rosemond and Turner dry basins have not been included in the area of agricultural land. Much of the land bordering the Southern Pacific

[1]U. S. Geol. Survey, Water Supply Paper No. 278.

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tract is yet railroad land. Aside from the La Liebre ranch and Palmdale Colony tract the land holdings are from 40 to 640 acres. Small farms are increasing in number. Some Government land remains open to entry in the outlying areas.

The chief crops grown are alfalfa, grain, almonds, pears, and apples, while alfalfa, pears, and apples are irrigated. The elevation is too great for citrus fruits. The irrigated almonds along the base of the San Gabriel Mountains west of Lancaster produce fairly well, although many orchards in this locality have been abandoned. Alfalfa produces five crops and averages from one to one and one half tons per acre for each cutting. The Little Rock Irrigation District supplies water by a ditch from Little Rock Creek to about 700 acres. About 300 acres of alfalfa is grown along Big Rock Creek. It is estimated that 1 miner's inch of water is sufficient for 5 acres of orchard where the water is piped. Under pumping plants it is stated that 1 miner's inch of water is required per acre for the first two years in irrigating new land after which time two thirds miner's inch per acre is sufficient. All of the pumping plants in this valley have been installed within the last three years. The limits of underground water have not been determined. The depth to water increases away from the artesian area. Water must be lifted from 40 to 70 feet near Neenach, 24 miles west of Lancaster. The lift near Palmdale is about 70 feet. New wells are continually being drilled where it is anticipated that the pumping lift will not be over 50 feet. About 105 pumping plants have been installed. Many artesian wells are grouped about Lancaster and Esperanza and others are scattered throughout the artesian area, the total number of flowing wells being 300.

The surface flow of Big Rock Creek has been used by irrigators for some 20 years and rights are based on this long-continued use. The flow of Little Rock Creek was formerly divided between the Little Rock Irrigation District and the Palmdale Colony Company, but the latter allowed their rights to lapse through disuse and the district now claims all of the natural flow of the creek. A reservoir site with capacity of 50,000 acre-feet is reported as being located on Rock Creek where its flood waters might be stored. Another site with capacity of 12,000 acre-feet is located immediately south of Palmdale and this basin was formerly used to store water from Little Rock Creek. It was intended to irrigate 10,000 acres about Palmdale from this supply. Meagre information is had regarding other reservoir sites located on Cottonwood and La Liebre creeks. It is proposed to develop water on these streams for use on the La Liebre ranch of 10,000 acres. The Little Rock Irrigation District is extending its acreage and ultimately expects to have 3,500 acres under its ditch. It is proposed to revive the old Antelope Valley Water Company which in the nineties organized the Palmdale Colony and to irrigate 3,500 acres of land from the Palmdale reservoir.

It is difficult to estimate the available water for Antelope Valley The rainfall varies from minimum of 3 inches on the desert to a maxi

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mum of 24 inches in the mountains. The watershed is 620 square miles. Numerous small streams which reach the plains from the mountain slopes are absorbed in the sands. Assuming a rainfall of 12 inches over the 260 square miles and 20 per cent of this as the amount reaching the underground basins, 33,280 acre-feet would be added annually. The ultimate irrigated area is estimated at 40,000 acres.

DESERT BASINS IN SAN BERNARDINO COUNTY.

Mesquite Valley borders the Nevada State line in the extreme northeastern corner of San Bernardino County. It contains 30,000 acres of Government land, none of which is irrigated. It is a desert basin with no surface outlet and is at an elevation of 2,500 feet. Both alkali and hardpan are reported to be present in localities. Springs are located in Kingston or Nopah Mountains, but little is known regarding underground waters, and this would be the only source of supply for irrigation. Mesquite Valley is 25 miles distant from the Tonapah and Tidewater Railway.

Ivanpah Valley is on the Salt Lake, Los Angeles and San Pedro Railroad in San Bernardino County near the Nevada line. It is at the foot of the Providence and New York ranges and drains to a dry lake bed within the area. It contains 223,000 acres, none of which is irrigated. The land has a good slope for irrigation and supports cactus and desert brush. It is all above the 2,900 foot elevation. Springs and creeks discharge from 1 to 3 miner's inches throughout the summer at the rim of the basin. Underground water is secured at a depth of 75 feet in the low area and at not over 200 feet on higher lands. Some wells are being drilled and pumping plants installed for the irrigation of small tracts. Plans are announced for the construction of a tunnel in Providence Mountains in the hope of developing 100 miner's inches of water.

Barnwell Sink is 25 miles northwest of Needles in San Bernardino County at an elevation of 3,000 to 4,000 feet. It contains 154,000 acres, of which none is irrigated. The land slopes well for irrigation and is not damaged by alkali. In late years filings were made and some were abandoned. Attempts were made to dry-farm lands, which resulted in failure. Later water was reached at 40 feet in a well 220 feet deep, and several hundred acres were seeded to grain and alfalfa to be irrigated. The idea prevails that underground water conditions are fairly good in the western part of the basin. The watershed includes drainage from the New York and Piute Mountains on the north and east. Piute and Vontrigger Springs are among the best on the desert and are drawn upon by the railroad. Barnwell Sink is on a branch of the Santa Fe Railway.

A desert sink is located southwest of Needles in San Bernardino County, and another is in Riverside County touching the San Bernardino County line. Both are 10 to 15 miles from Colorado River and neither is reached by rail. Each contains 115,000 acres. The soil ranges from shifting sand to sandy loam and the land belongs to the

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Government. Dry farming was tried and failed in the northern sink. Little is known of underground waters, but they are reported at depths of 200 to 500 feet. The basins are 800 feet above Colorado River and underground water must be relied on if land is irrigated.

DESERT BASINS IN KERN COUNTY.

Desert Springs Valley is between Mojave and Randsburg on the Nevada and California Railroad. It is in the southeastern corner of Kern County and east of the Los Angeles aqueduct. It is a basin that slopes northward to Dry Salt Lake at the rate of about 30 feet per mile. It is just north of Antelope Valley and has an elevation of 2,000 to 2,900 feet above sea level. Some of the land was filed on about two years ago and a few small pumping plants are irrigating tracts of 5 to 10 acres of alfalfa each.

The total area is 119,000 acres and about 200 acres are irrigated. Small canyons enter the basin from the mountains on the southwest. Water is secured at from 100 to 200 feet toward Dry Salt Lake; but near Mojave it is at greater depths and in limited amount. Alkali is found near the lake and hardpan underlies the land at varying depths.

Indian or Salt Wells Valley is on the Nevada and California Railroad and east of the Los Angeles aqueduct in the northeast corner of Kern County. It is a basin in which surface water accumulates in so-called dry lakes. The area is 112,000 acres. About 500 acres of alfalfa is irrigated by settlers who filed on Government land in 1910. Injurious salts are found in the eastern portion and hardpan is present at depths of several feet. This area has a fairly good watershed on the west. Underground water is secured at 150 to 200 feet, while water in limited amount is secured in some places at 30 to 40 feet.

DESERT BASINS IN INYO COUNTY.

Rose Valley is on the Nevada and California Railroad and borders the Los Angeles aqueduct between Haiwee Reservoir and Little Lake. It is 15 miles south of Owens Lake and in Inyo County. The land drains to Little Lake. The elevation is 3,000 to 3,700 feet. The basin has some characteristics of both a mountain valley and Mojave Desert land. Settlers who have made desert filings are scattered over the area and have small pumping plants. The basin contains 21,000 acres, of which 100 or more acres of alfalfa are irrigated. Underground water is secured at depths of 150 feet.

Twelve Mile or Chicago Valley is east of the Tonopah and Tidewater Railroad and between the Funeral and Kingston ranges in Inyo County. It contains 8,100 acres, of which 60 acres of alfalfa, grapes, and vegetables are irrigated with water from Resting Springs. The drainage is into a dry lake bed. Nearly all of the land remains in title of the Government. The elevation is over 2,200 feet. Underground water in quantities for domestic use can be had at depths from 100 to 200 feet. The extent of the waters has not been determined sufficiently to justify a statement regarding extensive irrigation development.

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Pahrump Valley and its extension, Stewart Valley, contain 20,400 acres in Inyo County, none of which is irrigated. A much larger area is in Nevada, but the best land is in California. This area is 10 miles east of the Tonopah and Tidewater Railroad and Amargosa River. The elevation is from 2,400 to 2,600 feet. The land belongs to the Government. The drainage is to a dry lake. Springs are located in the basin, but data are not available on underground water.

Amargosa Desert is principally in Nevada, but the part in Inyo County, California, contains 15,000 acres. No irrigation development has taken place. The area considered as agricultural land is all north of Scranton on the Tonopah and Tidewater Railroad. The desert is higher than Amargosa Valley and has an elevation of 2,400 feet. The land slopes to the east at the rate of about 50 feet per mile. The desert is at the base of the Funeral Range. Little is known of the possibility of securing water for irrigation. Amargosa Valley is in Nevada and California. The portion in California is not classed as agricultural. Amargosa River rises in Nevada and sinks in California, its waters finally reaching Death Valley. Information regarding Death Valley is meager. This land has not been classed as agricultural.

Summary for Mojave Desert.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.	Possible sources of water for further development.
Mojave River Valley and mesas	910,000	10,000	50,000	Storage on Little Bear Creek and Mojave River and underground waters.
Antelope Valley	485,500	4,629	40,000	Storage in mountain canyons and underground waters.
Desert basins in San Bernardino County	637,000	----------	8,000	Underground waters.
Desert basins in Kern County	231,000	700	10,000	Underground waters.
Desert basins in Inyo County	64,500	160	5,000	Underground waters.
Totals	2,328,000	15,489	113,000	

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SUMMARY FOR SOUTHERN CALIFORNIA.

The foregoing report deals with the irrigation resources of southern California in so much detail that it was thought best to outline general conditions in the introduction at the beginning of the report, and also in the briefer introductions and in the summaries concerning each of the divisions into which this portion of the State was segregated for purposes of this study. The following summary gathers together the areas of agricultural land, the areas irrigated, and the areas it is estimated will ultimately be irrigated:

Summary of agricultural, irrigated, and estimated irrigable lands of southern California.

Area.	Agricultural land. Acres.	Irrigated land. Acres.	Estimated area that will ultimately be irrigated. Acres.
Santa Barbara and Ventura counties	509,250	49,656	322,500
Los Angeles and San Gabriel River lands	441,986	167,454	381,500
Santa Ana River lands	876,671	213,407	279,000
San Diego County	363,668	19,880	87,100
Colorado Desert and River valleys	1,550,750	279,600	766,500
Mojave Desert	2,328,000	15,489	113,000
Totals	6,070,325	745,486	1,949,600

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WATER RESOURCES INVESTIGATIONS IN CALIFORNIA.

The measurement of the flow of streams in California was begun by the California State engineer in 1878, in accordance with the law requiring him "to investigate the problems of the irrigation of the plains, the condition and capacity of the great drainage lines of the State, and the improvement of the navigation of rivers." The work was restricted to a few localities in the Sacramento and San Joaquin River basins, the principal station being on the Sacramento at Collinsville.

The State Engineer's office was discontinued in 1884, and practically no further stream studies were made until 1894, when engineers of the United States Geological Survey were sent into California and made a few measurements of streams in the semi-arid parts of the State. The following year the Geological Survey established a station on the Sacramento River at Red Bluff and since that time has gradually extended the work as additional funds were available.

The early stream gaging work of the United States Geological Survey was primarily to obtain data in the interest of irrigation. Gaging stations were established in the foothill regions on the more important tributaries of the Sacramento and San Joaquin rivers, and in the southern part of the State. Several reservoir sites, principally in the Sacramento drainage, were surveyed as it was early realized that the low water flow would be insufficient for irrigation purposes.

The appropriations by Congress for water resources investigations were so limited that, unaided, the Geological Survey was unable to carry on as extensive investigations as were necessary in California. Realizing that the development of the State largely depended upon the utilization of its vast water resources, the legislature has from time to time made appropriations for coöperation with the Geological Survey, through the State Engineer, in these investigations. These funds were sufficient to maintain gaging stations on the more important streams available for irrigation.

The reclamation of large areas of arid and semi-arid lands in the State has greatly accelerated the development of California. Cheap power must be available if the remarkable growth of the State is to be maintained. Although but a small per cent of the possible water power has been developed, California now ranks as the second State in the Union in the total water power development.

Stream flow measurements for water power development must be on the headwaters and tributaries far above the foothill stations maintained for irrigation. As a rule the desired stations are at isolated points and difficult to reach. On this account the investigations are

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expensive to maintain. Through the coöperation of the United States Forest Service valuable water power records are being obtained, which would be practically impossible to secure in any other way. Considerable stream gaging work is being carried on by private parties and corporations throughout the State. Many of these coöperate with the Geological Survey or furnish their records for publication. It is realized that legitimate developments will be assisted in this manner.

The Conservation Commission, in making its inventory of the natural resources of the State, at once realized that additional stream flow data were imperative and hence in August, 1911, entered into the following agreement with the Geological Survey:

WHEREAS the United States Geological Survey is authorized by Congress to gage the streams and determine the water supply of the United States and to prepare reports on the best methods of utilizing the water resources, and in pursuance of that work has organized and equipped a corps of engineers, the members of which have become specially trained in the technical necessities of such investigations, and is maintaining an office at San Francisco, California, for the purpose of facilitating such investigations in that State; and

WHEREAS the Conservation Commission of the State of California is authorized to make an investigation of the natural resources of said State, and for this purpose requires:

First, a complete digest of all available data concerning the flow of the streams in the State of California;

Second, records of streams not hitherto investigated;

Third, surveys of the streams showing slope, topography, and such other data as may be necessary to determine water-power and storage possibilities along said streams; and

WHEREAS the Conservation Commission requires the information aforesaid at an earlier date than the same can be furnished by the Geological Survey with its present appropriation for this purpose, or by the Conservation Commission through independent effort and without the organization and equipment of the Geological Survey; and

WHEREAS the Geological Survey and the Conservation Commission believe that the most economical, expeditious, and satisfactory results may be secured by coöperation in such investigations;

Therefore, the following agreement:

This Agreement, made and entered into this seventh day of August, 1911, by and between the United States Geological Survey, the first party, and the Conservation Commission of the State of California, the second party, *Witnesseth*:

First—That the first party shall recommend to the second party such trained men as may be needed to prosecute the investigations aforesaid, such men to be additional to those employed in the regular work of the first party;

Second—That the first party shall advise with the second party in regard to investigations which the latter desires to maintain, and to direct the course of, and supervise the same in accordance with the methods used by the first party in similar investigations;

Third—That the first party shall furnish such instruments, supplies, equipment, forms, and stationery as may be needed in the work; provided, that it is understood that this shall not include the purchase of any special equipment not usually required in the investigations of the first party;

Fourth—That the first party shall furnish to the second party at such intervals as may be requested by the latter reports of investigations in progress, and in addition thereto shall furnish on October 1, 1912, a complete report containing

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all data collected as a result of this agreement together with similar data already in possession of the first party;

Fifth—That the first party shall publish without cost to the second party in the regular Survey publications the results of all data collected under this agreement as soon as possible after the completion of the investigations hereunder provided;

Sixth—That the second party shall designate to the first party the nature and location of the investigations and studies which it may desire to have made and shall specify the sum of money which it desires to expend for each line of investigation;

Seventh—That the second party shall pay the salaries and expenses of all men appointed by it for the prosecution of investigations included in this agreement;

Eighth—That the second party shall pay for all special equipment necessary for the carrying on of the investigations aforesaid.

UNITED STATES GEOLOGICAL SURVEY.
(Signed) GEO. OTIS SMITH, Director.
CONSERVATION COMMISSION OF THE STATE OF CALIFORNIA.
(Signed) GEO. C. PARDEE.
(Signed) FRANCIS CUTTLE.
(Signed) J. P. BAUMGARTNER.

In order to carry out the second provision of this agreement the Conservation Commission made an initial appropriation of $12,500. The new work was immediately begun by the Geological Survey and about 75 stations were installed on the headwaters and tributaries of the principal rivers of the State available for power and irrigation developments. Many of these stations were installed on streams which had not hitherto been investigated. The engineers, working under the directions of the Geological Survey, are employed, and their salary and necessary traveling expenses paid, directly by the State. The original appropriation was sufficient to maintain this new work for one year. In order that these investigations may be maintained at their present status until the State is able to make increased appropriations for this work, the Conservation Commission later alloted $10,000 additional. This amount, in addition to the regular funds, will insure the continuance of the present work until July 1, 1913.

The State of California now has available stream flow records adapted to all uses, including domestic water supply, irrigation, power, drainage, flood prevention, and navigation, at 289 points scattered through every portion of the State. The length of the records vary from a few months to several years. It is impossible to tell just how long it is necessary to maintain a gaging station in order that the absolute maximum and minimum, as well as the normal flow, may be determined. To be reliable, the record must extend over several years at least; and of course the longer the record, the more valuable it becomes.

The State Board of Control (Water Powers), now the State Water Commission, appropriated $4,000 to assist the Geological Survey in carrying out the first provision and $7,500 for the Survey as provided

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for in the third provision of the coöperative agreement. The State Engineering Department also furnished $2,500 for a survey of the San Joaquin River.

Maps of the following rivers have been prepared, showing the fall and the adjacent topography:

Pit River.
Middle Feather River, mouth to Nelson Point.
American River and tributaries.
Tuolumne River, Lagrange dam to Hetch Hetchy Valley.
San Joaquin River.

As provided in the coöperative agreement, the Geological Survey has made "a complete digest of all available data concerning the flow of the streams in the State of California," and at an expense of about $16,000 for printing, has published the following Water-Supply Papers:

295. Gazetteer of surface waters of California, Part I, Sacramento River basin.
296. Gazetteer of surface waters of California, Part II, San Joaquin River basin.
297. Gazetteer of surface waters of California, Part III, Great Basin and Pacific coast streams.
298. Water Resources of California, Part I, Stream measurements in Sacramento River basin.
299. Water Resources of California, Part II, Stream measurements in San Joaquin River basin.
300. Water Resources of California, Part III, Stream measurements in Great Basin and Pacific coast river basins.

The gazetteers, papers 295-297, cover the entire State and embrace descriptions of all the streams named on the best available maps. Each stream is described as rising near the point at which its beginning is shown on the map, and the elevation at that point is given as the elevation of the source. It is, of course, recognized that this method does not give results of great precision, but it probably causes no greater errors in the determination of length and fall than would be caused by extending each stream to the head of the divide between its basin and that of the adjoining streams. It should be understood, however, that all statements of elevation, length, and fall are merely approximate. A complete list of the gaging stations maintained in each basin is included in these papers.

The stream measurement reports, papers 298–300, describe the streams that have been measured and the stations at which the work has been carried on, and presents the results of the studies of stream flow. The investigations of the quantity of water in the streams have been supplemented by studies of the climatic and other factors affecting stream flow, and a mass of valuable information has thus been collected affording data for all phases of hydraulic work. These reports contain

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all the stream flow data that have ever been collected by the Geological Survey in California to June 30, 1912. Many private records are also included in these papers.

Previous reports of the Geological Survey relating to the water resources of California have been published, as follows:

IRRIGATION.

17. Irrigation near Bakersfield, California. Grunsky.
18. Irrigation near Fresno, California. Grunsky.
19. Irrigation near Merced, California. Grunsky.
45. Water storage on Cache Creek, California. Chandler.
46. Reconnaissance of Kern and Yuba rivers, California. Olmsted and Mason.
68. Water storage in the Truckee basin, California-Nevada. Taylor.
86. Storage reservoirs on Stony Creek, California. Cole.
89. Water resources of the Salinas Valley, California. Hamlin.
219. Ground waters and irrigation enterprises in the foothill belt, Southern California. Mendenhall.

SURFACE WATERS.

17. Irrigation near Bakersfield, California. Grunsky.
18. Irrigation near Fresno, California. Grunsky.
19. Irrigation near Merced, California. Grunsky.
45. Water storage on Cache Creek, California. Chandler.
46. Reconnaissance of Kern and Yuba rivers, California. Olmsted and Mason.
58. Storage of water on Kings River, California. Lippincott.
59. Developments and application of water near San Bernardino, Colton, and Riverside, California. Part I. Lippincott.
60. Developments and application of water near San Bernardino, Colton, and Riverside, California. Part II. Lippincott.
68. Water storage in the Truckee basin, California-Nevada. Taylor.
81. California Hydrography. Lippincott.
86. Storage reservoirs on Stony Creek, California. Cole.
89. Water resources of the Salinas Valley, California. Hamlin.
116. Water problems of Santa Barbara, California. Lippincott.
147. Destructive floods in the United States in 1904. Murphy.
162. Destructive floods in the United States in 1905. Murphy.
237. The quality of the surface waters of California. Van Winkle and Eaton.

UNDERGROUND WATERS.

57. Preliminary list of deep borings in the United States. Part I (Alabama-Montana).. Darton.
58. Storage of water on Kings River, California. Lippincott.
59. Developments and application of water near San Bernardino, Colton, and Riverside, California. Part I. Lippincott.
60. Developments and applications of water near San Bernardino, Colton, and Riverside, California. Part II. Lippincott.
89. Water resources of the Salinas Valley, California. Hamlin.
112. Underflow tests in the drainage basin of the Los Angeles River. Hamlin.
137. Development of underground waters in the eastern Coastal Plain region of southern California. Mendenhall.
138. Development of underground waters in the central Coastal Plain region of southern California. Mendenhall.
139. Development of underground waters in the western Coastal Plain region of southern California. Mendenhall.
142. The hydrology of San Bernardino Valley, California. Mendenhall.
149. Preliminary list of deep borings in the United States (Second edition, with additions). Darton.

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181. Geology and water resources of Owens Valley, California. Lee.
219. Ground waters and irrigation enterprises in the foothill belt, southern California. Mendenhall.
222. Preliminary report on the ground waters of San Joaquin Valley, California. Mendenhall.
224. Some desert watering places in southeastern California and southwestern Nevada. Mendenhall.
225. Ground waters of the Indio region, California, with a sketch of the Colorado Desert. Mendenhall.
278. Water resources of Antelope Valley, California. Johnson.
294. Ground water resources of a portion of Owens Valley, California. Lee.

These papers are distributed free to persons interested in these data. A few of the early papers are now out of print but may be consulted at the principal libraries and at the offices of the Geological Survey at San Francisco and Los Angeles. Copies of the later publications may be secured through the local offices or from The Director, U. S. Geological Survey, Washington, D. C.

VALUE OF WATER RESOURCES INVESTIGATIONS TO THE STATE OF CALIFORNIA.

Among the purposes for which the results of the investigations of the water resources of California are requisite are domestic water supply, irrigation, water power (including mining), flood prevention, drainage, and navigation.

Domestic Water Supply.—The highest use of water is that of domestic water supply. This use of water has so broad a significance with respect to the general welfare that every citizen of our State is ultimately and intimately concerned. Our large cities are now spending large sums in surveys and construction to insure a more abundant and satisfactory water supply for municipal purposes. The time is not far distant when our smaller towns, which have as yet given little attention to this matter, will be forced to provide more satisfactory water systems if their rapid development is to continue.

Irrigation.—Many millions of dollars have been expended on irrigation systems within the State. Not all of this money was spent wisely, due largely to the fact that stream flow records were incomplete or almost wholly lacking. The integrity of any irrigation system is based absolutely on the amount of water available. Irrigation is largely responsible for the almost unprecedented development that has taken place in California. The cheapest and easiest developments have already been constructed. To greatly extend the irrigated areas it will be necessary to augment the natural low water flow of our streams. This may be accomplished by conserving the flood flow of our rivers and releasing the water as needed, during the irrigation season. In order that the reservoirs may be properly designed it is absolutely necessary to have reliable run-off records for the drainage area.

Water Power.—The development of the water power of the State is

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an economic necessity. Cheap power must be available for our factories, and for municipal and agricultural purposes. But few of our streams are now furnishing the needed power—not one is developed to its capacity. As in irrigation, only the more accessible and cheap projects have been constructed. The early developments were, of necessity, built near the points where the power was to be used. With the improved machinery and transmission systems now in use, power plants may be built at isolated points. Storage must also be provided during the low water season for large developments. Inasmuch as the amount of water power that may be made available is dependent on the flow of the rivers, the investigation of flow becomes a prerequisite in the judicious development of this source of energy.

Flood Prevention.—The annual damage from floods in California is very great. It is now recognized that to control our rivers during the rainy season it will be necessary to construct large storage reservoirs in the mountains and foothills. The water thus conserved will not only insure relief from disastrous floods but will be available for irrigation and power purposes during the period of low water flow. It is evident that any comprehensive study of flood prevention must be based on a thorough knowledge of stream flow, both in the contributing areas which furnish the water and along the great lowland rivers.

Drainage.—The study of run-off is the first consideration in connection with drainage projects. If by the drainage of a large area in any particular channel that channel becomes so gorged with water that overflow conditions are created in places not previously subject to inundation, then drainage results merely in an exchange of land values. This is not the purpose of drainage improvements.

Navigation.—It is obvious that the determination of stream flow is necessary to the intelligent solution of the many problems herein involved.

Water is without doubt the most abundant and most valuable mineral in the State. Unlike the gold of the Sierra or the oil of the south, the supply may remain undiminished from year to year if the principles of conservation are applied. Extensive areas of irrigable land await reclamation; powerful streams are yet to be harnessed to operate our railroads, mines, and factories, light and heat our homes, and serve us in many ways not at this time anticipated.

In order to interest capital in the development of the water resources of the State we must have definite and convincing data regarding the flow of all of the streams within our borders. Irrigation bonds, which at the present time are not an attractive investment, will be readily negotiable when reliable stream-flow records establish the success of the project.

To insure the continuance of the present prosperity of California and provide for the tremendous developments that are inevitable if wisely assisted, the State must adequately provide for the continuance of these investigations.

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Subterranean Storage of Flood Water by Artificial Methods in San Bernardino Valley, California

By CHARLES H. LEE

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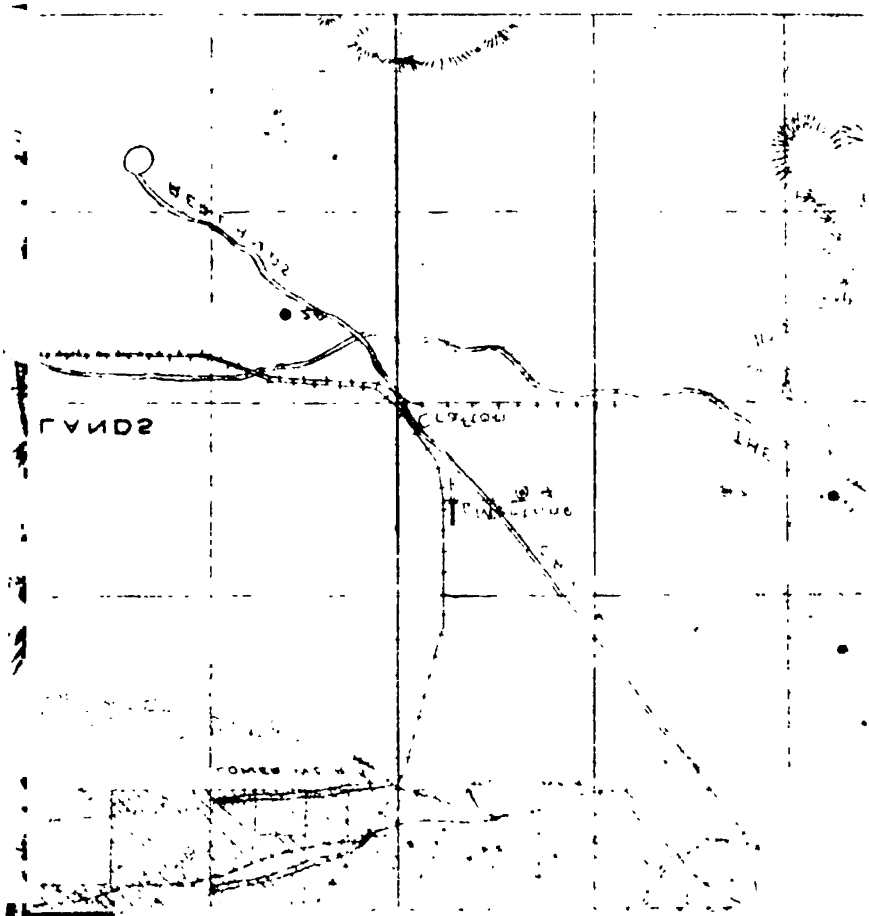

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Subterranean Storage of Flood Water by Artificial Methods in San Bernardino Valley, California.

By CHARLES H. LEE.

The great value of the ground water resources of Southern California has been so fully demonstrated by their development and use during the last thirty years that there has grown up an urgent public demand for knowledge regarding them. The existence of ground water, its sources, extent, movement, and ultimate disposition have been until recent years things of mystery not only to the man who was financially interested in their development, but also to the engineer. The demand for information and the exceptional opportunity afforded in southern California for scientific study of the principles governing ground water have led to investigations of the subject by various branches of the United States Government as well as by other organizations. The results of such investigations have made possible certain definite conclusions which have been sufficiently verified to be accepted as fact.

The commercial ground waters of southern California occupy the voids around the particles of gravel and sand filling the closed structural basins represented by the topographic valleys.[1] Each of these basins is a subterranean reservoir for ground water whose supply is water which percolates downward from flowing surface streams and from precipitation upon the surface of the gravels.[1] The natural outlet from these reservoirs is by spring and seepage flow into surface channels, by evaporation from damp soils and vegetation and, to a limited extent, by underflow.[2] The average annual rate of recharge by percolation equals the aggregate rate of outflow through these various available channels.[2] It follows from these facts that water artificially extracted from a basin either by pumping or through artesian flow, which does not return by percolation, reduces by that amount the volume of water passing from the basin by way of natural channels. It is also apparent that the average amount of water artificially drawn from a ground water reservoir can not exceed the rate of recharge less the natural overflow without seriously lowering ground water levels.

The amount of water developed from many of the large basins of southern California is dangerously near the limit, so that methods of conserving and increasing the available supply are necessary. This can be accomplished artificially either by the reduction of natural evaporation losses from areas of shallow ground water, or by increasing the volume of water percolating into the gravels. Both methods can and are being employed to increase the volume of commercially available ground water. This paper describes the methods used to artificially increase the supply by percolation from waste flood water in the San Bernardino Valley, California, discusses the observed effect of the work already done and its future possibilities.

[1] Mendenhall, W. C., Water-Supply Papers U. S. Geol. Survey Nos. 137, 138, 139, 142, 225.

[2] Lee, Charles H., Water-Supply Paper U. S. Geol. Survey No. 294, 1912.

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The investigations were carried on for the California State Conservation Commission under the direction of the writer who received valuable suggestions and advice from Mr. W. C. Mendenhall of the United States Geological Survey. Field work was commenced in March, 1912, and continued until November 1st. It is unfortunate that the available time and funds did not permit the extension of the work through a whole year, so that a careful field study of natural percolation from stream channels could be made and more complete well data gathered.

A large part of the detail field work was done by Mr. W. H. Spear, who also assisted in the preparation of maps and tables accompanying the report. Much valuable information was obtained from the Riverside Water Company, whose officers supplied all data in their possession which would throw light on the problem. The Water Conservation Association also furnished their records and rendered every possible assistance in carrying on the work.

WATER SPREADING.

The possibility of increasing ground water supply in southern California by artificially checking winter floods from the mountain canyons and spreading them over the porous gravel slopes first suggested itself to those interested in water development about twelve years ago. The extreme drought of the preceding years had led to the adoption of every conceivable method of water development. It was often observed that while stream channels were absolutely dry at points some distance from the mountains, there would be water flowing from the canyons above even in midsummer. The great reliability of ground water sources from which water could be obtained by artesian or pumped wells was also beginning to be apparent. The dependence of underground water supplies upon percolation from surface waters was a natural conclusion. Prof. E. W. Hilgard was probably the first to suggest in scientific literature the possibility of artificial replenishment of ground water supplies.[1] He proposed the storage of a portion of the waste flood waters of the Santa Ana River and Mill Creek by spreading them over the broad gravel slopes on either side of Santa Ana River, and regarded such a procedure to be as practical as surface storage in the mountains. The first attempt to put the idea into practice was made earlier than 1900 by the Gage Canal in diverting the Santa Ana floods on to the sandy wash below Orange Street. During the winter of 1901 some of the local water companies at Pomona did similar work on the débris cone of San Antonio Creek.[2] The results were encouraging in both localities and the work was continued. During the last few years similar work has been done on Lytle Creek, San Jacinto River, Santiago Creek, and San Gabriel River with satisfactory results. The idea has, therefore, passed the experimental stage

[1]Subterranean Water-Supply of the San Bernardino Valley, Report of Irrigation Investigations for 1901, Bull. U. S. Dept. Agr. No. 119, 1902, pp. 133-134.

[2]Tait, C. E., The Use of Underground Water for Irrigation at Pomona, Cal., Bull. U. S. Dept. Agr. Office of Exp. Stas., No. 236, 1912.

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as a method of flood water conservation. There remains, however, much engineering work to be done in devising methods and structures for diverting torrential flood waters and getting them into the gravels before reasonably complete conservation is possible.

History of Santa Ana work.

The term "water spreading" has been used locally in the San Bernardino Valley to describe the diversion of flood waters from the channel of the Santa Ana River and their distribution over the adjacent lands. The work was carried on through the individual efforts of the Riverside Water Company and Gage Canal prior to the year 1909. The value of the work was recognized, however, and efforts were made by the local water companies and public-spirited citizens to provide for its future permanency. In the spring of 1909 the federal government by legislative act set aside certain public lands to be used as spreading ground. (Statutes 36, page 641, under date of February 20, 1909.)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled. That all of the public lands in section eight, township one south, range two west, and in sections two, four, eight, ten, and twelve, in township one south, range three west, San Bernardino base and meridian, in the State of California, are hereby withdrawn from settlement and entry and reserved for the purpose of aiding in the conservation of the waters of the San Bernardino Valley: *Provided*, that this act shall not defeat any vested right which has attached under any pending entry or location.

SEC. 2. That any individual or association of individuals, or any company or corporation may have the right under such rules and regulations as the Secretary of the Interior may prescribe, to conduct to said lands and to distribute over them any flood or waste waters not otherwise appropriated, and to build the necessary engineering works, for this purpose, to the end that said flood or waste waters may sink into the sands and gravels of said lands, thereby increasing and replenishing the supply of underground water in the San Bernardino Valley.

The lands thus set aside are practically worthless as agricultural land, being composed of wash material situated in the lowest depression of the valley to the north of the present flood water channel of the Santa Ana (Plate I). These lands are desirably located for the purpose of spreading water, however. They are described according to the public survey as follows: The southwest quarter, south half northwest quarter, northwest quarter southeast quarter, section 8, township 1 south, range 2 west, San Bernardino meridian; northwest quarter, north half southwest quarter, southwest quarter southwest quarter, north half southeast quarter, southwest quarter southeast quarter, section 12; southeast quarter southeast quarter, section 2; northwest quarter northeast quarter, south half northeast quarter, south half southeast quarter, southwest quarter, south half northwest quarter, section 10; east half northeast quarter, section 4; township 1 south, range 3 west, San Bernardino meridian, and comprise 1,240 acres. There are 80 acres of this in the east half northeast quarter, section 4, township 1 south, range 3 west, which are too high to be reached from Santa Ana River, but which lie across the channel of City Creek and can be used for spreading water from that stream.

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An organization of citizens representing the local water companies was perfected June 2, 1909. It was named the "Water Conservation Association" and was organized as a coöperative association incorporated under the laws of the State of California. The articles of incorporation of the Association are as follows:

Know all men by these presents that the undersigned have associated themselves together to form a coöperative association, under and in accordance with the provisions of Sections 653b to 653l of the Civil Code of the State of California, and for that purpose hereby state and certify that:

(1) The name of said corporation is WATER CONSERVATION ASSOCIATION.

(2) The purpose for which it is formed is to conserve the surface and subsurface waters of the Santa Ana River and its tributaries situated in the counties of San Bernardino, Riverside and Orange, in the State of California:

a. By spreading the winter flood waters of said river and its tributaries, in the San Bernardino basin and elsewhere, over such lands adjacent to the channel thereof, as may be available for that purpose.

b. By securing control of such lands as may be necessary or desirable for such spreading, by purchase, lease, gift, donation, license or other methods, as may be found most desirable.

c. By the construction, maintenance and operation thereon of such works as may be found most advantageous and desirable for the purpose.

d. By prevention of waste of artesian and subsurface waters of said stream and the tributaries and sources of supply thereof, by the enforcement of the law of this State prohibiting waste of such water, and by securing evidence of such violation, and by the prosecution of the violaters of said law.

e. By such other methods of conserving the waters of said stream and its tributries as the Board of Directors of the association shall determine.

(3) The place where its principal business is to be transacted is the office of the Riverside Water Company, in the city of Riverside, county of Riverside, State of California.

(4) The term for which it is to exist is fifty years.

(5) The number of directors thereof is nine; three of whom shall be residents of the county of San Bernardino, three residents of the county of Riverside, and three residents of the county of Orange.

(6) The names and residences of the directors selected for the first year, and to serve until the election and qualification of their successors are as follows:

Names.	Residences.
Herbert N. Garstin	Redlands, Cal.
Geo. M. Cooley	San Bernardino, Cal.
Kenneth MacRae	Rialto, Cal.
W. G. Fraser	Riverside, Cal.
E. O. Rickard	Riverside, Cal.
Francis Cuttle	Riverside, Cal.
Wm. McLaughlin	Anaheim, Cal.
M. Nisson	Santa Ana, Cal.
E. E. Keech	Santa Ana, Cal.

(7) The amount which each member is to pay upon admission, as membership fee, is five ($5.00) dollars and each member signing these articles has actually paid in said sum, and that the interest and right of each member therein are to be equal.

This Association has been active in carrying on the work since its organization. An effort has been made to acquire lands lying between the areas reserved by the government so as to command a continuous strip one mile in width from the mouth of Santa Ana Canyon to the lower part of the valley (Plate I). So far there have been purchased from private ownership 680 acres, described as follows; west half southeast quarter, section 7, township 1 south, range 2 west; east

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half, and northwest quarter, section 11; and north half southeast quarter, northeast quarter of northeast quarter, section 10, township 1 south, range 3 west. There has also been secured the right to flood 240 acres owned by the city of Redlands, namely: south half northeast quarter, and southeast quarter, section 9, township 1 south, range 3 west. In addition to these lands, the Riverside Water Company owns the north half northwest quarter, and north half northeast quarter, section 9, township 1 south, range 3 west, upon which water is spread, and the Riverside Trust Company southeast quarter, section 8, southwest quarter and south half northwest quarter, section 9, township 1 south, range 3 west, which the Association has the right to flood. There are thus 2,640 acres of land now controlled by the Association along the Santa Ana River for the purpose of spreading flood water.

A notice of appropriation of water, as required by the laws of California, was posted by the Association October 3, 1911, at two points along the flood water channel of Santa Ana River on government land withdrawn from entry. The appropriation is for 25,000 miner's inches measured under a four-inch pressure, which is equivalent to 500 second feet. The text of the notice is as follows:

The undersigned hereby claims 25,000 inches of water measured under a four-inch pressure flowing in the channel of the Santa Ana River at the several points where this notice is posted, to wit:

1st: At a point from which the quarter section corner on the south boundary line of section 8, T. 1 S., R. 2 W., S.B.M., bears south 14 deg. 0 min. E. 2,066 feet.

2d: At a point from which the quarter section corner on the east boundary line of section 12, T. 1 S., R. 3 W., S.B.M., bears north 47 deg. 10 min. east 1,810.10 feet.

All such points and places of diversion being located on the public reservations of the United States.

The purpose for which the same is claimed is to conserve such waters by spreading the winter flood waters of said river and its tributaries over certain lands, to wit:

1st: All of the public lands in section 8, T. 1 S., R. 2 W., and in section two, four, eight, ten and twelve in T. 1 S., R. 3 W., S.B.M., in the State of California.

2d: The west half of S. E. quarter of section 7, in T. 1 S., R. 2 W., S.B.M., State of California.

3d: The east half and the N. W. quarter of section 11, T. 1 S., R. 3 W., S.B.M., State of California.

4th: The N. E. quarter of the N. E. quarter and the N. half of the S. E. quarter of section 10, T. 1 S., R. 3 W., S.B.M., in the State of California.

5th: The south one half of the N. E. quarter and the S. E. quarter of section 9, T. 1 S., R. 3 W., S.B.M., in the State of California.

The means by which it is intended to divert said waters is by a headgate or boulder dam, or both, ditch, iron pipe, and flume or any or either of such means as may be found most practicable. The size of such ditch at the first point of diversion named above is to be 16 feet wide and 3 feet deep and the size of such ditch at the second point of diversion named above is to be 20 feet wide and 3 feet deep, or larger if necessary, to carry the amount of water here claimed. In event that it should be deemed advisable to construct an iron pipe or flume, or both at such points of diversion, such iron pipe and flume are to be of sufficient capacity to carry the amount of water here claimed.

Dated: October 3, 1911.

WATER CONSERVATION ASSOCIATION.
(Signed) By FRANCIS CUTTLE, President.

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The Association has also been active in making provision for carrying on systematically and permanently the work of spreading water. A one-story concrete building with floor space about 20 feet wide and 40 feet long has been erected on the northwest quarter southeast quarter, section 7, township 1 south, range 2 west, land which is owned by the Association. Here men employed in the water spreading work are housed during the flood flow period and during the remainder of the year the building serves as a storehouse for tools and equipment used on the work. There has also been constructed a concrete headgate (Plate II, A) on the north bank of the Santa Ana near the mouth of the canyon at the point where the first notice of appropriation was posted. From this point, from a point opposite the junction of Mill Creek, the point of filing of the second notice of appropriation just below the Santa Fé Railroad bridge, rough ditches have been laid out and constructed to carry flood waters from the river channel on to the spreading grounds (Plate II, B). Concrete weirs (Plates II-A and III) with sheet steel crests have been installed in each ditch near the headgates. The middle diversion ditch crosses Orange Street, leading from Redlands to East Highlands, and an appropriate concrete culvert has been built at this point to carry the water underneath the road. In addition to making these various improvements the Association has kept a foreman and three or four men at work each season diverting and spreading flood water. The making of improvements and the work of water spreading have been done under the direction and direct supervision of Mr. C. S. Wilson, who is also superintendent of the Riverside Water Company. Mr. Francis Cuttle, of Riverside, is president of the Association and has taken a very active interest in the work, being largely responsible for the organization of the Association and the progress thus far attained.

The funds of the Association are derived from membership dues and from assessments levied upon the companies represented by the members, namely: Gage Canal Company, Riverside-Highland Water Company, Riverside Water Company, and Santa Ana River Development Company. The expenditures of the Association to June 12, 1912, have been very kindly furnished by Mr. Cuttle and as they indicate in a general way the size of the work they will be stated. The cost of all improvements, including the building, headgates, weirs, ditches and culvert, has been $4,371.66. The real estate has cost $2,853. The tools purchased to date amount to $163.83. Operating expenses for three seasons, 1909-10 to 1911-12, were $3,619.45; during the season 1911-12 were $903.46, and average about $1,200 per season. The total expenditures to June 12, 1912, were $11,007.94.

Method of spreading water.

The area over which the flood waters of the Santa Ana are being spread is the surface of the alluvial slope in front of the mouth of Santa Ana Canyon, which the river has built up with alluvial material carried by it from the canyon. The carrying power of a stream depends upon

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the velocity of the water, which in turn depends upon the grade. The grade of the stream in the canyon is so steep that boulders several feet in diameter are moved during severe floods and smaller boulders are carried along like pumpkins. The thundering of these stones as they strike one another in their mad rush can be heard several miles away. The larger boulders are all deposited at and near the mouth of the canyon at the apex of the cone. Smaller boulders, coarse gravel, fine gravel and sand are deposited in the order named as the stream velocity becomes less and less in passing down the slope. Oftentimes the channel will be so choked with débris near the canyon mouth that a subsequent flood finds a course for itself in an entirely new position on the slope. This channel in turn is abandoned for some other, leaving two parallel lines of boulders to mark the old position. Thus the upper portion of the slope is a jumble of boulder heaps and ridges. In passing down the slope there are small clear spaces of gravel and sand which increase in area to the lower slope, which is one broad unbroken surface of sand except where cut by the present river channel. The length of this slope from the mouth of the canyon to the valley floor is about ten miles and it occupies the full width of the valley, finally merging into the main San Bernardino Valley.

The first attempts at water spreading were made by the Riverside Trust Company for the purpose of increasing the supply of the Gage Canal. It was noticed that while the large floods were in progress the débris-laden water was confined to no definite channel on the middle and lower portion of the alluvial slope, but spread out in a broad sheet obliterating all existing channels. As the flood abated this sheet became comparatively shallow and a large proportion of the flow at the mouth of the canyon would be absorbed by the gravels before reaching the region of shallow ground water near the head of the Gage Canal. As the flow still further decreased, however, the stream would leave the canyon without a load of sand and gravel, and as it advanced down the slope would cut a more definite channel for itself in some portion of the broad flood channel. The broad sheet was thus concentrated into a relative narrow and deep stream with a minimum area of water surface in contact with the absorbent gravels. Under these modified channel conditions a much smaller stream would flow across the gravel slope to the region of shallow ground water than was possible immediately after the flood crest had passed. Water thus entering the region of shallow ground water passed the Colton dike and was lost to the ocean.

The idea which guided the work of the Riverside Trust Company was to artificially maintain the early channel conditions of a waning flood. This was done by throwing up temporary embankments across the broad flood channel just as soon as the fury of a flood had abated, so that the water could be checked and ponded, and if necessary spread out laterally from the channel. The work was done between Orange Street and the head of the Gage Canal, where the slope flattens out and broad areas of fine gravel and sand lie adjacent to the flood channel. The

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method proved effective in conserving the flow of the Santa Ana durin and after the period of channel readjustment which follows the large floods. It was not possible to control the main body of the flood by thi method. Furthermore, by spreading the water so near the region fro which ground water was developed for use, the practical effect wa merely to store the water from spring to the following summe Although such monthly regulation is good, yet the crying need on a southern California streams is for annual storage regulation. Whe the dry year comes without its spring floods, there will be no water fo spreading and it is then that water stored during the preceding w years should be at hand. This can be accomplished by spreading th flood water higher up on the slope. This idea has been followed t a certain extent by the Water Conservation Association. The gener

Plate II-A. Upper diversion ditch.

method used by the Association in getting the flood water into th gravels is to divert a large head of water from the river, carry it in contour ditch, or established channel, to land suitable for spreadi and there distribute it into smaller ditches from which it is furth distributed and finally allowed to spread out over the surface and si into the gravel. The best spreading ground has an unbroken surfa with gentle slope and more or less desert vegetation. The soil shou be free from clay or silt. The finer wash material composed of sand a gravel is very good. The area of good spreading ground is very limit on the upper alluvial slopes. There is a greater proportion on th middle slope between the Santa Fé Railroad and Orange Street, a below Orange Street almost all of the ground can be used to advantag In handling the water great care must be exercised to prevent it fro cutting. As soon as a small channel in the natural surface is forme

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he water will start flowing rapidly and cut deeper and wider until a ash is formed, down which water goes with a rush and can not be ontrolled. The most effective percolation occurs when the water moves lowly over the unbroken natural surface. The water can actually e seen to disappear as it advances in a thin sheet over such surface.

The three ditches which are being used are shown on Plate I. They re situated so as to command most of the lands available for water preading. The upper ditch is about half a mile in length and follows enerally the contour of the land (Plate II-A). It diverts water rom the north bank of the main wash about one mile below the mouth f Santa Ana Canyon and carries it in a general northwest direction o be spread on the smoother lands below the ditch. The surface of he alluvial slope immediately below this ditch is somewhat broken y old channels and boulders, but there are numerous small areas of ravel and sand which afford fair ground for spreading. The area of uch land is probably less than 100 acres. The general grade of the and below this ditch is about 200 feet per mile.

The middle diversion system has a capacity approximately equal to he combined capacities of the two other ditches. Its length is about our miles. The point of diversion from the main channel of the river is about one third of a mile west of the junction of Mill Creek. The iversion channel follows the natural slope and is locally known as the orth Fork of Santa Ana River, being an old flood channel of the river. itches have been constructed from various points along this channel, hrough which the water is led on to the adjacent lands. The grade f the land along the upper portion of the channel is about 125 feet er mile and decreases to 50 feet and less per mile toward the lower nd. Water can be carried to both the middle and lower alluvial slopes hrough this channel. During 1912 considerable water was carried hrough it to the lands west of Orange Street.

The lower ditch diverts from the north bank of the main Santa Ana ust below the Santa Fé Railroad crossing. It has a length of possibly two miles, follows generally the slope of the ground, and consists of both artificial and natural channels. The slope of the adjacent ground is about 120 feet per mile. The ditch covers some very good water spreading land between the main wash and the middle ditch.

The work of the men engaged in water spreading is to keep the main ditches in repair, to lead the water into the lateral and sublateral ditches, and to keep the water under control by preventing it from cutting. Portions of the ditches are excavated in the sand and gravel and other portions are diked so that constant watching is necessary when they are carrying large heads of water. The distribution of water needs to be continually rearranged as certain areas become temporarily saturated or water commences cutting. It has been found very desirable not to break the natural surface with a shovel for such places give the water opportunity to start cutting. Many of the laterals are constructed by shoveling out a small trench which the water will soon excavate to the desired size. The area over which the water has been

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spread thus far is a very small proportion of that available. The first two years' work was carried on above Orange Street, but in 1912 considerable spreading was done west of the street, where conditions were very favorable for spreading a large volume of water at small cost. Four men are kept busy full time during the spreading season in handling the water which is diverted.

The floods of the Santa Ana are torrential in character and in their early stages carry large quantities of fine silt, the result of abrasion of the gravel and boulders which the stream picks up and transports down the canyon. As long as the water maintains its high velocity this silt remains in suspension, but when diverted into the contour ditches and spread out on the surface the silt settles and forms an impervious skin over the surface. This slime completely seals the porous materials from the entry of percolating water and thus greatly reduces the efficiency of the water spreading work. The policy has been not to take this silty water into the ditches. When a flood occurs the headgates are closed and not opened until the water clears again, usually after the lapse of two or three days. The large floods are so violent that the rough boulder diversion dams are often carried away and the present headgates would probably be endangered if it was attempted to divert during the high stages. Hence with the existing methods and equipment it is not desirable to attempt to spread water during period of maximum flood flow.

Amount of water spread.

There has been no record kept of the amount of water diverted and spread prior to the spring of 1912. It is estimated by Mr. John Heaslet, engineer for the Riverside Water Company, who was familiar with the work done by the Conservation Association, that there were from ten to twenty second-feet diverted for possibly three months during the winter of 1908–09. The amount diverted in 1909–10 was less than this, due to the small winter flow of the streams. In 1910–11 Mr. Heaslet made three sets of current meter measurements, as follows: February 21st, upper ditch 20 second-feet; middle ditch 27 second-feet; lower ditch 40 second-feet, or 87 second-feet total; March 1st, upper ditch 22 second-feet; middle ditch 30 second-feet; lower ditch 40 second-feet, or 92 second-feet total; May 20th, upper ditch 22 second-feet; middle and lower ditches dry. The high water period of that season extended from January 24th to about May 1st. The maximum total amount diverted during the season was probably not in excess of 92 second-feet and can be reasonably considered as 75 second-feet for one hundred days or about 15,000 acre feet.

There were weirs installed in the three ditches just below the headgates in the fall of 1911, prior to the first appearance of flood water. These were constructed of concrete and steel, there being a wall of concrete across the ditch section with a sheet steel plate imbedded in it. The weir notch was of the rectangular type with complete end contractions, length of crest 10 feet, depth of notch 2 feet. The conditions are not ideal for accurate measurements, the steel being set into

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the concrete too far to give good sharp-crested conditions. The upper weir has insufficient free fall (Plate II, B), while the middle weir has high- (Plate III) and the lower weir medium-velocity of approach.

Plate II-B. Headgate and weir at head of upper diversion ditch.

Sand tends to collect rapidly behind the weirs so that it requires constant attention to keep them in condition for use. Observations were made daily during the spring of 1912 by the foreman of the

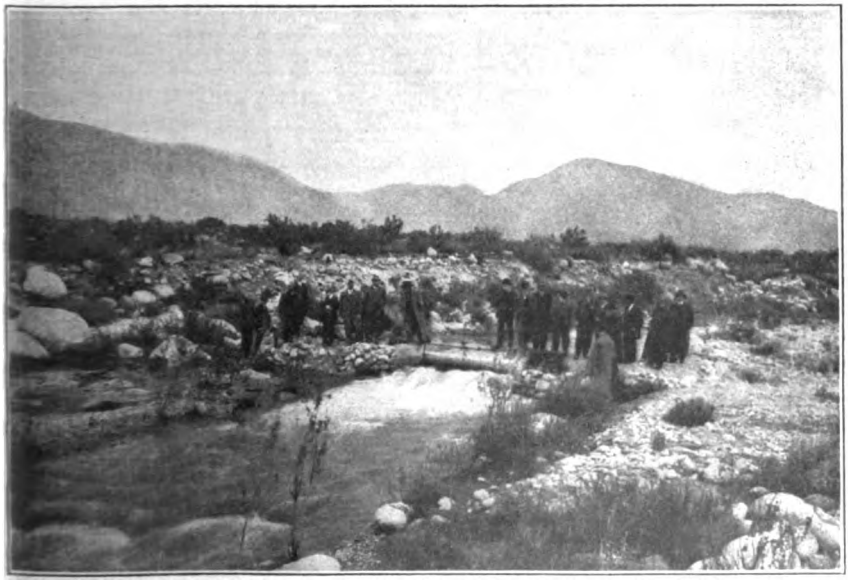

Plate III. Weir on middle diversion ditch.

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water spreading crew who used a carpenter's foot rule and observed to the nearest inch the depth of water over a stake set level with the weir crest. The results of his measurements are presented in Tables 1 to 3. The river channel was entirely dry until early March, 1912, so that the spreading season was short. The total amount diverted was 9,157 acre-feet with a maximum daily discharge of 137 second-feet. Practically all of the water diverted has been absorbed before returning to the wash. The maximum combined discharge capacity of the present diversion works and ditches is not in excess of 250 second-feet and it is doubtful whether four men could handle this amount of water and at the same time keep the main ditches in repair.

Summarizing it can be said that the amount of water spread by the Association during the season 1908–09 was between 2,000 and 3,000 acre-feet and that the volume of water spread in any preceding season did not exceed this. The amount spread in 1909–10 was less than that spread during 1908–09. During the season of 1910–11 the amount spread was about 15,000 acre-feet and during 1911–12 was 9,157 acre-feet. The annual operating cost has averaged about 10 cents per acre foot of water spread, and interest at 6 per cent on the permanent investment 4 cents per acre-foot. The duty of water varies from 2 to 3 acre-feet per acre per year in this region. Hence the annual cost of storing surplus flood water in the gravels is less than 30 cents per acre irrigated therefrom. The average annual return per acre from irrigated land in the vicinity of Riverside is stated to be $150. The cost of subterranean storage is therefore very reasonable.

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TABLE 1.

Daily discharge of ditches diverting flood water from Santa Ana River on to spreading ground. March, 1912.

Day.	Discharge in second-feet.			Total.
	Upper weir.	Middle weir.	Lower weir.	
1	.0	.0	.0	.0
2	.0	.0	.0	.0
3	.0	.0	.0	.0
4	.0	.0	.0	.0
5	.0	.0	.0	.0
6	14.7	62.6	59.3	136.6
7	11.6	43.8	21.3	76.7
8	11.6	39.4	14.8	65.7
9	11.6	35.3	6.4	53.3
10	11.6	52.8	59.3	123.7
11	17.8	52.8	50	120.6
12	14.7	52.8	50	117.5
13	17.8	52.8	50	120.6
14	21.3	52.8	50	124.1
15	17.8	52.8	41.2	111.8
16	17.8	52.8	32.6	103.2
17	17.8	48.4	28.8	95.0
18	14.7	48.4	28.8	91.9
19	17.8	48.4	32.6	98.8
20	17.8	43.8	25	86.6
21	17.8	43.8	41.2	102.8
22	17.8	52.8	36.8	107.4
23	17.8	52.8	32.6	103.2
24	11.6	35.3	17.8	64.7
25	11.6	31.2	11.6	54.4
26	4.1	27.2	8.8	40.1
27	4.1	31.2	11.6	46.9
28	4.1	27.2	11.6	42.9
29	4.1	27.2	8.8	40.1
30	6.4	31.2	17.8	55.4
31	4.1	27.2	11.6	42.9
Mean second-feet	11	36.3	24.5	71.8
Total acre-feet	675	2,230	1,508	4,413

Observations by Water Conservation Association.

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TABLE 2.

Daily discharge of ditches diverting flood water from Santa Ana River on to spreading ground. April, 1912.

Day.	Discharge in second-feet.			Total.
	Upper weir.	Middle weir.	Lower weir.	
1	4.1	31.2	11.6	46.9
2	2.3	31.2	11.6	45.1
3	2.3	31.2	14.7	48.2
4	2.3	31.2	14.7	48.2
5	2.3	31.2	11.6	45.1
6	2.3	31.2	14.7	48.2
7	4.1	35.3	14.7	54.1
8	4.1	35.3	14.7	54.1
9	9	39.4	21.3	69.7
10	6.4	39.4	28.8	74.6
11	17.8	48.3	59.3	135.4
12	17.8	43.8	41.2	102.8
13	17.8	48.3	41.2	107.3
14	17.8	48.3	41.2	107.3
15	17.8	43.8	41.2	102.8
16	17.8	43.8	41.2	102.8
17	17.8	39.4	36.8	94.0
18	21.3	43.8	36.8	101.9
19	14.7	43.8	36.8	95.3
20	11.6	43.8	32.6	88.0
21	8.8	39.4	25	73.2
22	8.8	39.4	21.3	69.5
23	8.8	39.4	21.3	69.5
24	8.8	39.4	25	73.2
25	6.4	35.3	21.3	63.0
26	6.4	27.2	14.7	48.3
27	6.4	39.3	25	70.7
28	6.4	35.3	21.3	63.0
29	4.1	27.2	8.8	40.1
30	.0	.0	.0	.0
Mean second-feet	9.2	36.8	25	71.0
Total acre-feet	548	2,187	1,487	4,222

Observations by Water Conservation Association.

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TABLE 3.

Daily discharge of ditches diverting flood water from Santa Ana River on to spreading ground. May, 1912.

Day.	Discharge in second-feet.			Total.
	Upper weir.	Middle weir.	Lower weir.	
1	.0	.0	.0	.0
2	.0	.0	.0	.0
3	.0	.0	.0	.0
4	.0	.0	.0	.0
5	.0	.0	.0	.0
6	.0	.0	.0	.0
7	.0	.0	.0	.0
8	.0	.0	.0	.0
9	.0	.0	.0	.0
10	.0	.0	.0	.0
11	4.1	31.2	14.7	50.0
12	6.4	35.3	14.7	56.4
13	6.4	35.3	14.7	56.4
14	4.1	31.2	9	44.3
15	6.4	35.3	14.7	56.4
16	.0	.0	.0	.0
17	.0	.0	.0	.0
18	.0	.0	.0	.0
19	.0	.0	.0	.0
20	.0	.0	.0	.0
21	.0	.0	.0	.0
22	.0	.0	.0	.0
23	.0	.0	.0	.0
24	.0	.0	.0	.0
25	.0	.0	.0	.0
26	.0	.0	.0	.0
27	.0	.0	.0	.0
28	.0	.0	.0	.0
29	.0	.0	.0	.0
30	.0	.0	.0	.0
31	.0	.0	.0	.0
Mean second-feet	0.9	5.4	2.2	8.5
Total acre-feet	54	334	134	522

Observations by Water Conservation Association.

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Other efforts at water spreading.

The subterranean storage of waste flood water has been tried not only on Santa Ana River, but on San Antonio, Lytle and Santiago creeks and San Jacinto and San Gabriel rivers. There have been somewhat different methods employed on some of these streams for bringing the water in contact with the gravels and an interesting comparison can be made. The writer visited the spreading ground on San Jacinto River and Lytle Creek, and saw the work in progress. The work on both these streams is being carried on in restricted ground water basins, which can be easily controlled by a single financial interest as regards inflow and draft. Water which is absorbed by the gravels can be developed at a lower point later in the season with almost absolute certainty.

The Turk Basin on Lytle Creek is an enlarged portion of the Lytle Creek Canyon, two miles above its mouth, which is filled with the coarse débris deposited by the upper stream. The bedrock walls of the cañon almost meet at the entrance and exit of the basin, but between, widen out to a distance of more than half a mile. The length is a little greater than one mile and the slope of the ground surface nearly 200 feet per mile. The basin is operated by the Fontana Development Company as a monthly storage regulator of the flow of Lytle Creek. The company diverts the flow of the stream for irrigation uses, and reports that the water spreading work is very effective in increasing the gravity flow during the late summer at the lower end of the Turk Basin. The restricted area of contact and the steep grade of the surface have led the company to adopt the "shaft" method in getting the water into the gravels. This consists in sinking shafts into the porous material of the upper basin and diverting flood water into them to be absorbed by the surrounding formation.

The shafts are located in the upper and middle part of the basin and are approximately 4 by 6 feet in cross section. They were sunk to porous gravels and varied in depth from 50 to 70 feet below the surface. They are lagged with 2 inch redwood lumber with 8 and 10 inch horizontal sets, each set separated by a ¾-inch space. Settling basins are provided near each shaft but flood waters are not admitted until the stream clears of silt. The engineer of the company, Mr. C. M. Racor, reported that the shafts would take from one to two second-feet each. The company has about 12 shafts in this basin. Water is diverted from the creek by means of a temporary boulder dam which each flood carries away. The operating expenses consist of the labor of three or four men a day, for a day or two after each storm, who rebuild the dam, and look over the distributing ditches and shafts. This method is particularly adapted for use on steep ground where desirable spreading area is limited. The cost of the shafts is about $5 per foot. Assuming they were sunk 75 feet, absorbed 300 acre-feet per year and had a life of five years, the interest and depreciation cost would be 32 cents per year per acre-foot. The method might be employed to advantage on the Santa Ana fan above the Santa Fé Railroad.

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The work on San Jacinto River is being carried on by the Citizens Water Company below the mouth of the canyon and at the head of San Jacinto Valley. There is a more or less distinct basin here formed by the granite range to the north and the relatively impervious fan of Bautista Creek. The outlet of this basin is at the cienaga, located just above the junction of Poppet and Bautista creeks with San Jacinto Wash, at which point the company has installed a pumping plant. The spreading ground is situated along the river channel for several miles above the cienaga. The surface is an unbroken slope of sand with a grade of from 50 to 30 feet per mile. The basin method is being employed here. Areas of several acres extent are enclosed with levees thrown up by teams and scrapers. Water is diverted from the river into the highest basins and overflows successively into the next lower basins. It is stated by Mr. Kingsbury Sanborn, engineer for the company, that the rate of percolation was in some cases as high as 5 second-feet per acre. It was found necessary to plow up the floor of the basins two or three times during the first season to break the silt deposit, and eventually it will be necessary to remove the silt from the basins. This method is well adapted to gently sloping ground, and with certain modifications might prove more effective on the Santa Ana fan in controlling the large floods than the broadcast spreading now practiced by the Water Conservation Association.

THE SAN BERNARDINO GROUND WATER RESERVOIR.

A study of the effect of water spreading over the Santa Ana fan upon ground water levels, and artesian flow in the San Bernardino Valley, is so closely related to the broader subject of natural ground water storage in the valley, that a brief description of the basin is advisable before considering the problem.

Generally speaking the basin is an ancient valley buried deep beneath modern alluvial material which has been transported from the San Bernardino Mountains by torrential streams which drain its southwestern slope (Fig. 1). The rim of the basin along the north and northeast is the steep rock face of the San Bernardino Range, along the south it is limited by the Crafton Hills and the relatively impervious formation referred to by Mendenhall as the older alluvium;[1] while it is closed on the west by a buried ridge known as the Bunker Hill dike[1] whose higher elevations appear as mounds above the modern alluvial material. There is a gap through this ridge in the vicinity of the present channel of the Santa Ana River. This gap is filled with alluvial material and the present river channel is but a few feet lower than the crest of the ridge. The gap was cut by the Santa Ana River in former geologic times. The bottom of the gap is the lowest depression in the impervious rim of the basin and the superimposed ground surface above is the lowest depression of the present topographic boundary. Hence

[1]Mendenhall, W. C., Hydrology of San Bernardino Valley, Cal., Water-Supply Paper No. 142, U. S. Geol. Survey, 1905, pp. 30-34.

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this vicinity is the natural and sole outlet of both surface and subterranean waters which flow from the basin.

The floor of the basin has varied topography which is probably very similar to that of the Perris and San Jacinto regions with their level valleys surrounded by hills and mountains. The depth of alluvial material exceeds 1000 feet in a deep well bored by the city of San Bernardino about one mile east of town. Less than 1½ miles north of this well the bedrock rises 150 feet above the surface at Perris Hill (Plate I). Similar conditions occur in other parts of the valley, but it is impossible to state the detail of this buried topography. There seems to be one feature, however, which is fairly well defined, namely, a range of hills lying about 2½ miles from and almost parallel with the base of the San Bernardino Range, extending from the point of the ridge between Lytle Creek and Cajon Wash in a southeast direction to the highest peak of the Crafton Hills. This range shows itself in the form of buttes and hills, such as Perris Hill, which rise from the surrounding alluvial material to various heights, and by low mounds not so prominent but of the same rock formation. There are three of these mounds along the flood channel of Mill Creek, just above its junction with Santa Ana Wash. The top of buried portions of this ridge have also been encountered at several points, as in the wells sunk by the city of San Bernardino at the new Perris Hill pumping plant, and in a well sunk near the east quarter corner of section 36, township 1 north, range 4 west.

The exact way in which the subsidence of this old topographic surface occurred and the resulting deep basin filled, will probably never be fully understood. The various streams from Cajon Wash to Santa Ana River all assisted in the filling of the basin. There is not enough evidence to determine whether the flow from all these streams was originally deflected to a common point of discharge through the hills, or whether several outlets existed. There are indications, however, that Plunge Creek, City Creek, and other small creeks to the southwest, and possibly Santa Ana River were thus deflected and found a common outlet, at the point of lowest depression which appears to have been near Harlem Springs. The fact that a portion of the bedrock has been cut away from the mountain slope at the west side of the mouth of Santa Ana Canyon, and that none of the older alluvium appears along the base of the range between Santa Ana and Plunge Creek canyons, would indicate that the Santa Ana River was deflected sharply to the west at some time during its history. The period was one of very active erosion and although at first the stream may have deepened the depression through which it passed, the coarse débris ultimately filled the long narrow valley and eventually the outlet. Individual outlets were then found at higher levels and eventually the streams swept over the tops of all but the highest peaks.

The early condition of the main basin was probably that of a deep lake. After the lake was drained the course of an important drainage

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channel from the San Bernardino Mountains was probably through the defile at Harlem Springs along the general position of Warm Creek, and through the gap in the dike. Mill Creek flowed directly west to the same gap and may have been joined by a large stream from the south. Lytle Creek also assisted in carrying alluvial material into the basin. The ultimate result of the work of these streams was to build up the floor of the valley to its present level and fix the present drainage lines. During all this time periods of great erosional activity were followed by those of comparative quiescence. Hence the material which fills the basin is a series of alternating layers of coarse gravel with sands and clays. There is every reason to believe that a continuous body of coarse material extends from behind the ridge of hills near the San Bernardino Mountains through the Harlem Springs defile and into the main basin, where it is spread fan-shape between layers of impervious clay. The relation of this body of gravel to that deposited by Mill Creek and its tributary and Lytle Creek is difficult to determine, as is also the relation of superimposed gravels carried at a later period over the crest of the ridge of buried hills. The clays, however, are limited to the lower part of the valley and probably do not extend much beyond the original artesian boundary mapped by Mendenhall.

The San Bernardino basin is thus a large structural basin filled with alluvial débris. This material is composed of coarse gravels in a wide zone along the base of the San Bernardino Mountains from Lytle Creek to Crafton Hills, and well out into the valley north of Redlands. Within the area of the central depression of the present valley the gravels are inter-bedded with clays. The natural drainage outlet is situated three miles directly south of the city of San Bernardino.

The void spaces of this gravel, which vary from 20 to 35 per cent of the total volume, constitute the water storage capacity of the basin. The sources of water supply are percolation from those portions of stream channels which are porous, percolation from irrigation water, and percolation from direct precipitation upon porous surface material. The first of these sources is the most important.

The movement of water percolating from streams is downward and laterally into the gravels to the broad surface of the permanent ground water body. The movement is then termed seepage and is down the ground water slope toward the region of lowest depression. The progress of seepage waters is variable and in all cases slow.[1] The lower portion of the valley to the south and east of the city of San Bernardino is the ultimate goal of all waters entering the gravels from whatever source.

Water filling the gravel strata beneath the clays of the central valley are under considerable hydrostatic pressure from ground water in the gravels at higher levels nearer the sources of supply. Such water is termed artesian and breaks through the clay where it is weak, thus forming springs and seepages which give source to such streams

[1]Mendenhall, W. C., Water-Supply Paper No. 142, U. S. Geol. Survey, 1905, pp. 49-50.

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as Warm Creek and its tributaries. The ground water level within the area of shallow artesian pressure is near the surface, and causes the swampy conditions so noticeable to the east and south of San Bernardino. Artesian water is drawn upon artificially by means of deep casing wells which puncture the overlaying clays. There have been more than one hundred such wells drilled within the artesian area.

The basin is a great subterranean storage reservoir. Hence all water that enters it must have an outlet. The natural outlets are by subsurface flow through the gap in the Bunker Hill dike, by evaporation from the swamp and moist lands overlaying the artesian area, and by overflow of springs and seepages into surface channels through which it flows from the basin across the dike. Warm Creek drains the north two thirds of the artesian area, and the channel of Santa Ana River the southern portion. The underflow at the gap through the dike is small in amount and need hardly be considered from a practical standpoint when studying the output of the basin as a whole. In recent years the artificial development of artesian and pumped water for use without the basin has constituted a fourth outlet. This artificial draft has correspondingly reduced the natural overflow from the basin by shrinkage of spring and seepage flow, and the evaporating area, but has not increased the total outflow. Considered as an average, natural inflow and outflow for the basin are equal in amount.

There are great monthly inequalities in the rate of recharge of the basin due to the concentration of annual precipitation and run-off into a few months of the year. There are also annual differences due to the broad annual variations of precipitation and run-off. These are shown to a certain extent in the rate of outflow from the basin. The monthly irregularities are registered by variable natural and artificial artesian flow; the annual changes by variation in the evaporating area as well as the amount of escaping artesian water. The major part of irregularities in inflow, however, is taken up by fluctuations of ground water level. This characteristic of a ground water storage reservoir gives it preëminent advantage over any other type of storage in a region subject to great precipitation extremes, such as southern California.

The problem of determining the effect of water spreading during the past few years upon the amount of water commercially available from the basin is solved by answering the following questions:

1. To what extent has water spreading increased the volume of water percolating into the gravels of the Santa Ana Fan?

2. Have ground water levels, artesian flow, or the boundary of moist land in any portion of the basin exhibited any fluctuations during the last few years which cannot be explained by variation in the rate of natural ground water supply?

3. Have ground water levels or output in any other ground water basin of southern California influenced solely by natural conditions, exhibited variations similar to those of the San Bernardino basin?

The remainder of this report presents and analyzes data which bears upon these questions.

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TABLE 4.

Precipitation in inches at San Bernardino, Cal.

Elevation 1054.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March	April.	May.	June.	Total.
1870-71	.0	.0	0.02	0.09	3.11	0.89	6.91	2.21	0.19	0.34	0.11	0.07	13.94
1871-72	.0	0.04	0.13	0.60	0.88	3.91	.0	2.20	0.37	0.79	0.06	.0	8.98
1872-73	.0	0.18	0.04	.0	1.17	4.40	6.50	1.25	0.51	0.84	0.21	.0	15.10
1873-74	.0	1.06	0.02	0.01	0.74	5.73	5.51	8.76	1.08	0.48	0.42	.0	23.81
1874-75	.0	.0	0.06	1.82	1.88	2.20	7.20	0.15	0.22	0.07	0.05	.0	13.65
1875-76	.0	.0	.0	.0	7.50	0.02	6.55	1.92	3.41	0.44	0.03	0.03	19.90
1876-77	.0	.0	.0	0.20	0.40	.0	3.50	4.03	0.83	0.26	0.30	.0	9.52
1877-78	.0	.0	.0	0.86	0.50	3.95	3.33	6.68	2.57	1.71	0.66	0.07	20.33
1878-79	0.07	.0	0.02	0.14	0.05	4.70	3.59	1.00	0.50	1.20	0.24	0.03	11.54
1879-80	0.11	0.02	0.01	0.94	3.40	6.50	1.56	1.33	1.45	5.00	0.04	.0	20.36
1880-81	.0	.0	.0	0.14	0.67	8.80	1.40	0.36	1.66	0.46	0.01	.0	13.50
1881-82	.0	.0	.0	0.80	0.27	0.50	1.11	2.65	3.30	2.91	.0	.0	11.54
1882-83	.0	.0	.0	0.10	0.15	0.45	1.60	1.10	2.82	2.95	.0	.0	9.17
1883-84	0.19	.0	0.53	0.85	0.09	2.63	1.63	12.20	9.95	5.68	3.17	0.59	37.51
1884-85	.0	.0	.0	.0	0.11	3.75	2.79	0.11	0.28	1.89	1.69	0.19	10.81
1885-86	.0	.0	.0	0.39	4.36	1.20	6.44	2.52	4.18	2.36	0.32	0.16	21.93
1886-87	.0	.0	.0	.0	0.11	0.61	0.39	6.44	4.41	1.90	0.42	0.22	14.50
1887-88	0.11	0.04	0.09	1.17	2.29	1.91	4.01	3.60	3.41	0.58	0.52	0.03	17.76
1888-89	.0	.0	.0	0.05	4.12	4.64	0.93	1.50	6.55	2.05	1.13	.0	20.97
1889-90	0.17	0.63	0.11	2.30	2.23	10.85	5.44	2.52	0.89	.0	0.31	.0	25.45
1890-91	0.13	2.16	0.88	0.58	1.27	3.02	.0	7.78	0.06	0.53	1.67	.0	18.08
1891-92	.0	0.91	0.93	trace	trace	1.67	3.24	3.30	1.75	0.37	2.10	0.08	14.35
1892-93	.0	trace	.0	0.16	1.02	2.23	4.53	3.37	8.00	0.48	0.03	.0	19.82
1893-94	0.20	.0	0.05	1.06	0.30	2.28	1.26	0.88	1.15	0.40	0.56	.0	8.13
1894-95	trace	0.16	0.37	0.15	.0	7.25	7.39	1.14	3.44	0.64	0.44	.0	20.98
1895-96	.0	.0	.0	.0	0.14	0.66	2.02	.0	2.92	0.37	1.00	.0	8.11
1896-97	trace	0.17	.0	2.10	0.98	1.09	3.40	5.40	3.41	0.08	0.11	.0	16.74
1897-98	trace	.0	0.13	2.10	0.21	0.57	2.10	0.60	0.97	0.48	1.08	.0	8.24
1898-99	.0	.0	.0	0.03	0.05	0.44	2.03	0.51	3.22	0.07	0.19	0.95	7.49
1899-00	.0	trace	0.01	0.81	1.47	0.84	0.92	.0	0.92	1.96	1.71	trace	8.64
1900-01	0.34	.0	0.23	0.36	6.10	.0	3.48	4.58	0.43	0.56	1.23	0.05	17.36
1901-02	.0	0.27	0.07	1.09	0.28	0.04	1.65	3.02	3.89	0.57	0.12	0.15	11.15
1902-03	0.01	.0	.0	0.09	1.94	1.94	1.96	1.67	6.47	3.10	0.24	.0	17.42
1903-04	.0	0.15	0.46	0.07	.0	.0	0.18	2.21	5.34	0.80	0.16	.0	9.37
1904-05	.0	0.14	0.06	0.32	.0	1.03	3.92	6.58	6.00	1.18	1.55	.0	20.78

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TABLE 4—Continued.

Precipitation in inches at San Bernardino, Cal.

Season.	July.	August.	September.	October.	November.	December	January.	February.	March.	April.	May.	June.	Total.
1905-06	.0	.0	0.13	0.01	2.81	0.74	2.97	2.89	8.00	1.16	0.96	0.22	19.88
1906-07	trace	trace	0.05	0.01	2.42	7.12	6.33	2.14	4.58	0.16	0.11	0.25	23.17
1907-08	.0	.0	.0	2.75	0.10	0.97	4.71	4.20	2.03	0.53	0.31	0.02	15.62
1908-09	0.05	.0	1.11	1.45	0.26	0.66	7.49	3.76	2.29	0.17	0.02	0.10	17.36
1909-10	.0	1.28	.0	0.04	2.28	7.19	2.43	0.06	1.58	0.14	.0	trace	15.02
1910-11	0.05	0.03	0.36	1.04	0.54	0.03	6.58	4.22	2.52	0.48	0.49	trace	16.34
1911-12	trace	.0	1.47	0.50	0.58	1.17	0.75	.0	5.18	3.67	0.52	(.0)	13.84
42-year mean	.03	.17	.17	.60	1.35	2.59	3.33	2.88	2.92	1.19	.58	.08	15.91

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TABLE 5.

Precipitation in inches at Riverside, Cal.

Elevation 851.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1881-82	.0	.0	0.10	0.40	0.25	0.40	1.70	1.40	1.08	0.72	0.08	0.18	6.31
1882-83	.0	.0	.0	0.13	0.29	0.20	0.09	0.83	0.89	0.26	0.25	.0	2.94
1883-84	.0	.0	.0	0.97	.0	2.25	0.84	7.94	6.56	1.67	1.99	0.52	22.74
1884-85	.0	3.00	.0	0.12	0.12	2.56	0.77	.0	0.01	2.15	0.24	.0	8.97
1885-86	.0	.0	.0	0.02	1.34	0.62	2.68	1.38	1.95	1.43	.0	.0	9.42
1886-87	.0	.0	.0	.0	0.54	0.04	0.13	3.30	0.02	1.70	0.17	0.02	5.92
1887-88	.0	.0	.0	0.75	0.87	0.85	4.17	1.05	3.84	0.18	0.05	.0	11.76
1888-89	.0	.0	.0	.0	2.83	3.37	0.87	1.30	5.10	1.83	0.25	.0	15.55
1889-90	.0	.0	0.09	1.35	1.82	7.80	4.44	1.96	0.60	0.06	0.09	.0	18.21
1890-91	.0	0.05	0.79	0.13	0.32	3.21	0.13	6.36	0.40	1.04	0.46	.0	12.89
1891-92	.0	.0	0.13	0.03	.0	1.29	.0	2.60	1.07	.0	1.32	.0	6.44
1892-93	.0	.0	.0	0.29	0.28	0.94	3.01	1.95	5.71	0.24	0.04	.0	12.46
1893-94	0.33	.0	1.27	1.08	0.67	2.05	0.69	0.33	0.70	.0	.0	.0	7.12
1894-95	.0	0.26	0.20	0.05	.0	5.22	6.48	1.09	2.54	0.29	0.26	.0	16.39
1895-96	.0	.0	.0	.0	1.25	0.24	1.72	.0	3.16	0.56	0.58	.0	7.51
1896-97	0.02	0.23	.0	2.07	1.48	0.92	3.38	3.07	1.62	0.03	0.03	.0	12.85
1897-98	.0	0.04	0.09	1.67	0.02	0.95	1.74	0.12	0.80	0.18	0.27	.0	5.88
1898-99	.0	.0	.0	.0	0.01	1.38	2.09	0.89	0.90	.0	0.13	0.30	5.70
1899-90	.0	.0	.0	1.03	0.57	0.41	1.01	0.01	0.95	0.74	1.29	.0	6.01
1900-01	.0	.0	.0	0.28	2.51	.0	2.67	2.74	0.12	.0	0.54	.0	8.86
1901-02	(0.02)	(0.18)	trace	0.80	0.12	trace	0.90	1.81	2.23	0.23	0.16	0.05	(6.50)
1902-03	trace	.0	trace	0.09	1.09	1.64	0.94	1.24	5.22	2.49	0.02	.0	12.74
1903-04	trace	trace	0.43	0.05	.0	0.03	0.15	1.21	3.22	0.58	0.08	.0	5.75
1904-05	0.07	trace	trace	0.21	.0	1.11	3.07	5.86	4.87	0.45	0.88	.0	16.52
1905-06	.0	.0	0.08	trace	2.73	0.48	1.38	1.44	6.86	1.57	0.52	0.08	15.14
1906-07	trace	trace	0.02	.0	2.23	4.43	4.02	1.75	3.49	0.14	0.07	0.16	16.31
1907-08	.0	.0	.0	2.91	0.02	0.90	3.93	2.77	0.92	0.28	0.21	.0	11.94
1908-09	0.10	0.02	0.77	0.59	0.11	0.65	4.89	2.73	1.87	0.11	0.09	0.09	12.02
1909-10	.0	1.23	.0	0.06	1.96	5.03	1.70	0.04	1.73	0.18	.0	.0	11.93
1910-11	.0	.0	.0	0.59	0.40	0.04	4.70	2.80	1.66	0.51	0.03	.0	10.73
1911-12	0.10	.0	0.75	0.40	.0	0.86	0.45	.0	3.64	1.79	0.38	.0	8.37
31-year mean	.02	.16	.15	.52	.77	1.61	2.09	1.93	2.38	.69	.34	.05	10.70

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TABLE 6.

Precipitation in inches at Redlands, Cal.

Elevation 1352.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1889-90	.0	0.28	0.31	1.50	0.52	13.72	4.69	3.03	0.89	0.16	0.68	.0	25.78
1890-91	.0	2.16	0.88	0.29	.0	3.02	.0	9.28	1.19	0.91	1.10	.23	19.06
1891-92	.0	1.63	0.97	.0	.0	1.51	0.87	4.37	2.06	0.13	.0	.0	11.54
1892-93	.0	.0	0.03	.0	0.63	1.58	3.02	3.93	7.22	0.26	.0	.0	16.67
1893-94	0.21	.0	0.69	0.95	0.50	3.46	1.43	1.04	1.01	0.25	0.64	.0	10.18
1894-95	.0	0.09	0.17	0.07	.0	7.38	8.66	1.30	3.29	1.37	0.57	.0	22.90
1895-96	.0	.0	.0	0.03	2.03	0.52	1.52	0.24	3.96	0.01	1.14	0.06	9.51
1896-97	0.01	2.00	.0	1.72	2.07	1.37	5.11	5.83	3.00	0.14	0.63	.0	21.88
1897-98	0.06	.0	0.83	2.38	0.16	0.70	1.96	0.79	0.99	0.31	2.15	.0	10.33
1898-99	0.10	.0	.0	0.04	0.22	0.62	1.92	0.71	1.50	0.08	0.24	0.87	6.30
1899-90	.0	0.04	0.05	0.65	1.28	0.46	1.20	trace	0.78	2.03	1.41	.0	7.90
1900-01	0.04	.0	0.50	0.53	3.88	.0	2.25	3.79	0.46	trace	1.62	0.04	13.11
1901-02	.0	.0	.0	0.92	0.09	trace	1.64	2.58	2.82	0.36	0.08	0.31	8.80
1902-03	0.07	.0	.0	0.06	1.40	1.50	1.16	1.41	5.86	3.88	0.48	.0	15.82
1903-04	.0	0.21	0.54	0.06	.0	.0	0.29	1.50	4.55	0.82	0.48	.0	8.45
1904-05	.0	0.18	.0	0.26	.0	0.24	6.15	6.74	5.53	0.27	1.16	.0	20.53
1905-06	.0	.0	.0	0.04	2.38	1.29	1.48	3.04	6.15	1.30	0.79	0.14	16.61
1906-07	.0	0.04	0.19	.0	2.72	5.21	5.90	2.08	4.30	0.47	0.38	0.61	21.85
1907-08	.0	.0	.0	3.37	0.24	0.77	4.44	3.12	1.56	0.52	0.30	0.04	14.36
1908-09	trace	0.22	1.31	0.96	0.02	0.98	5.06	2.87	2.25	0.16	0.57	0.07	14.47
1909-10	trace	0.19	0.06	0.05	1.67	4.43	1.99	0.19	1.57	0.25	.0	0.07	10.47
1910-11	0.38	trace	0.20	0.51	0.48	0.67	4.44	3.88	2.24	0.68	0.45	trace	13.93
1911-12	trace	trace	1.03	0.71	0.34	1.35	0.37	.0	5.87	2.85	1.73	.0	14.25
23-year mean	.04	.31	.34	.66	.90	2.21	2.85	2.68	3.00	.75	.72	.11	14.55

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TABLE 7.
Precipitation in inches at Upland, Cal.
Elevation 1750.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1891-92	.0	.0	.0	.0	.0	2.70	2.55	2.90	5.97	0.50	3.28	0.87	18.77
1892-93	.0	.0	.0	0.12	2.96	3.67	9.50	3.61	12.52	0.77	.0	0.08	33.23
1893-94	0.60	.0	.0	1.21	1.42	5.08	1.21	1.57	1.42	0.28	0.28	.0	13.07
1894-95	.0	0.34	0.58	0.03	.0	8.66	9.03	2.38	4.75	1.45	0.65	.0	27.87
1895-96	.0	.0	.0	.0	1.40	1.40	2.83	.0	5.25	0.70	0.93	.0	12.51
1896-97	0.04	0.60	.0	3.32	0.98	1.66	5.26	7.82	5.29	trace	0.07	.0	24.99
1897-98	.0	trace	.0	3.41	0.40	0.48	2.30	1.11	1.55	0.50	2.75	.0	12.75
1898-99	0.06	.0	trace	0.28	0.12	0.55	2.88	0.63	2.71	0.19	0.05	0.90	8.37
1899-00	.0	trace	0.05	1.78	1.78	1.05	1.75	0.19	1.93	1.68	2.77	.0	12.93
1900-01	.0	.0	0.64	0.40	8.17	.0	5.33	6.10	0.71	0.78	1.50	.0	23.63
1901-02	.0	.0	.0	2.59	0.75	0.06	1.51	2.92	5.78	0.29	0.13	0.05	14.08
1902-03	.0	.0	.0	0.41	2.05	2.54	3.97	2.10	9.45	4.00	0.63	.0	25.15
1903-04	.0	.0	0.42	.0	.0	.0	0.39	4.26	6.18	1.77	0.30	.0	13.32
1904-05	trace	0.07	.0	0.95	.0	1.09	4.30	7.92	6.87	0.88	3.54	.0	25.62
1905-06	.0	.0	0.17	0.02	2.96	0.90	3.88	3.00	14.03	2.42	2.65	0.20	30.23
1906-07	0.11	.0	trace	.0	0.75	9.10	9.71	3.19	7.32	0.53	0.12	0.84	31.67
1907-08	.0	.0	.0	2.14	0.22	1.11	7.15	4.35	1.40	1.32	0.60	.0	18.29
1908-09	trace	.0	1.86	1.03	0.36	1.27	11.08	7.04	3.95	0.17	.0	.0	26.76
1909-10	0.05	0.02	trace	0.36	2.33	11.41	2.83	0.56	2.35	0.29	.0	.0	20.11
1910-11	.0	.0	trace	0.38	0.82	0.23	11.10	6.25	6.02	1.28	0.55	.0	26.63
20-year mean	.04	.05	.19	.92	1.37	2.65	4.93	3.40	5.27	.99	1.04	.15	21.

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TABLE 8.

Seasonal precipitation in inches at San Diego, Cal.

Season.	Depth in inches.	Season.	Depth in inches.
1850-51	8.41	1882-83	4.92
1851-52	9.48	1883-84	25.97
1852-53	11.03	1884-85	8.67
1853-54	9.77	1885-86	16.96
1854-55	13.56	1886-87	8.32
1855-56	9.89	1887-88	9.82
1856-57	4.76	1888-89	11.02
1857-58	7.54	1889-90	15.02
1858-59	6.61	1890-91	10.47
1859-60	6.58	1891-92	8.70
1860-61	7.90	1892-93	9.26
1861-62	15.64	1893-94	4.97
1862-63	3.87	1894-95	11.90
1863-64	5.14	1895-96	6.21
1864-65	8.45	1896-97	11.78
1865-66	12.82	1897-98	4.99
1866-67	13.73	1898-99	5.24
1867-68	11.23	1899-00	5.97
1868-69	11.68	1900-01	10.45
1869-70	5.48	1901-02	6.17
1870-71	5.17	1902-03	11.76
1871-72	7.18	1903-04	4.40
1872-73	6.50	1904-05	14.32
1873-74	16.88	1905-06	14.68
1874-75	5.73	1906-07	10.62
1875-76	10.11	1907-08	8.55
1876-77	3.75	1908-09	10.23
1877-78	16.10	1909-10	9.79
1878-79	7.88	1910-11	11.99
1879-80	14.36	1911-12	10.75
1880-81	9.66		
1881-82	9.51	62-year mean	9.68

WATER SUPPLY.

The ultimate source of water supply for the San Bernardino basin is precipation upon the valley floor and the tributary mountain slopes. The precipitation falling upon the mountains becomes available to the valley as run-off in the streams which flow from the various cañons or catchment areas. The percolation from stream flow is the most important source of ground water supply, but since stream flow is primarily dependent on precipitation a broadly accurate knowledge of fluctuations in the rate of ground water supply can be obtained from a study of precipitation records.

Precipitation.

The problem under consideration deals with the distribution of precipitation, not geographically, but with regard to time. A few records typical of the whole region are therefore sufficient as a basis of study. The records selected are those published by the United States Weather Bureau for San Bernardino, Riverside, Redlands, and Upland (Tables 4 to 7). The Weather Bureau record at San Diego is also presented because of the long period covered and general similarity of precipitation conditions (Table 8), and the record at Los Angeles in connection with ground water conditions in San Fernando Valley (Table 9). The records are arranged according to the season, July 1 to June 30, which correspond with the run-off season.

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TABLE 9. *Precipitation in inches at Los Angeles, Cal.* (Elevation 203.)

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March	April.	May.	June.	Total.
1872-73	.0	0.22	.0	.0	.0	4.42	2.08	7.19	.05	.0	.0	.0	13.96
1873-74	.0	1.06	.0	.0	0.74	5.74	5.51	9.77	1.09	.45	.42	.0	24.78
1874-75	.0	.0	0.06	1.81	1.89	.20	17.22	.15	.22	.07	.05	.0	21.67
1875-76	.0	.0	.0	.0	7.57	.82	6.54	7.92	3.41	.45	.03	.0	26.74
1876-77	.0	.0	.0	.40	.0	.0	3.48	.01	.83	.26	.30	.0	5.28
1877-78	.0	.0	.0	0.86	0.45	3.93	3.33	7.68	2.57	1.71	0.66	0.07	21.26
1878-79	.0	trace	.0	0.14	trace	4.70	3.59	0.97	0.49	1.19	0.24	0.03	11.35
1879-80	.0	.0	.0	0.93	3.44	6.53	1.33	1.56	1.45	5.06	0.04	.0	20.34
1880-81	trace	trace	.0	0.14	0.67	8.40	1.43	0.36	1.66	0.46	0.01	.0	13.13
1881-82	.0	trace	trace	0.82	0.27	0.52	1.01	2.66	2.66	1.83	0.63	trace	10.40
1882-83	.0	.0	trace	0.05	1.82	0.06	1.62	3.47	2.87	0.15	2.02	0.03	12.11
1883-84	trace	.0	.0	1.42	.0	2.56	3.15	13.37	12.36	3.58	0.35	1.39	38.18
1884-85	trace	trace	trace	0.39	1.06	4.64	1.05	trace	0.01	2.00	0.06	trace	9.21
1885-86	trace	trace	trace	0.26	5.52	1.63	7.72	1.38	2.50	3.29	.0	0.01	22.31
1886-87	0.24	0.21	.0	0.01	1.18	0.18	0.20	9.25	0.24	2.30	0.20	0.04	14.05
1887-88	0.07	.0	0.15	0.12	0.78	2.67	6.08	0.77	3.15	0.11	0.02	trace	13.87
1888-89	0.03	0.08	trace	0.36	4.01	6.25	0.25	0.92	6.48	0.27	0.62	.0	19.28
1889-90	.0	0.28	0.33	6.96	1.35	15.80	7.83	1.36	0.66	0.22	0.08	0.02	34.84
1890-91	.0	0.03	0.06	0.03	0.13	2.32	0.25	8.56	0.41	1.26	0.31	.0	13.36
1891-92	trace	.0	0.06	.0	.0	1.99	0.88	3.19	3.39	0.22	2.06	0.06	11.85
1892-93	.0	0.01	.0	0.33	4.40	4.18	6.29	2.27	8.52	0.19	0.06	0.03	26.28
1893-94	.0	.0	trace	0.75	0.20	3.65	0.94	0.49	0.37	0.13	0.20	trace	6.73
1894-95	trace	0.01	0.73	0.02	.0	4.62	5.84	0.46	3.77	0.46	0.19	0.01	16.11
1895-96	trace	trace	trace	0.24	0.80	0.78	3.23	trace	2.97	0.19	0.30	trace	8.51
1896-97	0.02	0.01	trace	1.30	1.66	2.12	3.70	5.62	2.31	0.02	0.10	trace	16.86
1897-98	trace	.0	.0	2.47	0.01	0.05	1.26	0.51	0.98	0.03	1.75	trace	7.06
1898-99	0.07	trace	0.02	0.09	trace	0.12	2.64	0.04	1.81	0.18	0.04	0.58	5.59
1899-00	.0	0.01	trace	1.59	0.90	0.90	1.17	trace	0.99	0.54	1.81	trace	7.91
1900-01	trace	trace	trace	0.26	6.53	trace	2.49	4.38	0.45	0.68	1.50	trace	16.29
1901-02	trace	0.09	0.03	1.88	0.46	.0	1.62	3.35	2.98	0.16	0.03	trace	10.60
1902-03	trace	trace	trace	0.40	2.08	2.50	2.10	1.52	6.93	3.77	trace	0.02	19.32
1903-04	.0	trace	0.43	trace	.0	trace	0.14	2.68	4.50	0.97	trace	trace	8.72
1904-05	trace	0.17	0.28	0.69	.0	2.45	2.57	6.06	6.00	0.35	0.95	.0	19.52
1905-06	.0	.0	trace	0.08	2.98	0.20	3.85	2.47	7.35	0.69	0.02	0.01	18.65
1906-07	0.02	0.03	0.05	.0	0.85	5.12	7.02	1.83	4.12	0.16	0.07	0.03	19.30
1907-08	.0	.0	trace	1.19	trace	0.88	5.04	3.66	0.18	0.52	0.25	.0	11.72
1908-09	trace	0.08	1.22	0.25	1.08	1.46	7.27	5.20	2.51	trace	.0	0.11	19.18
1909-10	.0	trace	0.04	0.28	1.51	7.00	1.53	0.11	1.86	0.30	.0	.0	12.63
1910-11	0.04	trace	0.01	0.82	0.15	0.07	6.70	2.91	5.15	0.28	0.02	0.03	16.18
1911-12	trace	.0	1.23	0.16	0.10	1.27	0.07	.0	6.99	1.66	0.12	.0	11.60
40-year mean	.01	.06	.12	.69	1.36	2.77	3.50	3.10	2.93	.90	.41	.06	15.92

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TABLE 10.

Observed precipitation in inches at base stations in San Bernardino Valley.

Season July 1 to June 30.	San Bernardino.	Riverside.	Redlands.	Upland.
1870-71	13.94			
1871-72	8.98			
1872-73	15.10			
1873-74	23.81			
1874-75	13.65			
1875-76	19.90			
1876-77	9.52			
1877-78	20.33			
1878-79	11.54			
1879-80	20.36			
1880-81	13.50			
1881-82	11.54	6.31		
1882-83	9.17	2.94		
1883-84	37.51	22.74		
1884-85	10.81	8.97		
1885-86	21.93	9.42		
1886-87	14.50	5.92		
1887-88	17.76	11.76		
1888-89	20.97	15.55		
1889-90	25.45	18.21	25.78	
1890-91	18.08	12.89	19.06	
1891-92	14.35	6.44	11.54	18.77
1892-93	19.82	12.46	16.67	33.23
1893-94	8.13	7.12	10.18	13.07
1894-95	20.98	16.39	22.90	27.87
1895-96	8.11	7.51	9.51	12.51
1896-97	16.74	12.85	21.88	24.99
1897-98	8.24	5.88	10.33	12.75
1898-99	7.49	5.70	6.30	8.37
1899-00	8.64	6.01	7.90	12.98
1900-01	17.36	8.86	13.11	23.63
1901-02	11.15	6.50	8.80	14.08
1902-03	17.42	12.74	15.82	25.15
1903-04	9.37	5.75	8.45	13.32
1904-05	20.78	16.52	20.53	25.62
1905-06	19.88	15.14	16.61	30.23
1906-07	23.17	16.31	21.85	31.67
1907-08	15.62	11.94	14.36	18.29
1908-09	17.36	12.02	14.47	26.76
1909-10	15.02	11.93	10.47	20.11
1910-11	16.34	10.78	13.93	26.63
1911-12	13.84	8.37	14.25	
Number of years	42	31	23	20
Observed mean	15.91	10.70	14.55	21.04
Number of years	42	42	42	42
Deduced mean	15.91	10.61	15.07	22.70

The longest record in the San Bernardino Valley is that at the city of San Bernardino which covers 42 seasons from 1870-71 to 1911-12. The Riverside record extends over 31 seasons, Redlands 23 seasons and Upland 20 seasons. The mean computed from the shorter records is not as reliable as that for San Bernardino. Since precipitation conditions are similar at the four stations deduced means were computed for the shorter records by comparing the precipitation at San Bernardino during the same period with the full period at that station, and applying the correction factors to the shorter term means (Table 10). The percentage relation that each season's precipitation bears to the

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long period mean and the average per cent for the four stations was then computed (Table 11). It will be observed that the percentages at various stations agree closely and the average gives a more reliable value than would a single record. It will be noted that seasonal precipitation varies from a maximum of two and one fourth times the mean to a minimum of two fifths of the mean. Also that periods of four consecutive seasons have occurred with precipitation both above and below normal. Ground water fluctuations should, therefore, be subject to wide variations from natural causes.

TABLE 11.

Seasonal variation of precipitation expressed as per cent of deduced mean for stations in San Bernardino Valley.

Season July 1 to June 30.	San Bernardino.	Riverside.	Redlands.	Upland.	Average per cent for each year of all stations.
1870-71	88				88
1871-72	56				56
1872-73	95				95
1873-74	150				150
1874-75	86				86
1875-76	125				125
1876-77	60				60
1877-78	128				128
1878-79	72				72
1879-80	128				128
1880-81	85				85
1881-82	72	60			66
1882-83	58	28			43
1883-84	236	214			225
1884-85	68	85			76
1885-86	138	89			113
1886-87	91	56			73
1887-88	112	111			111
1888-89	132	146			139
1889-90	160	172	171		168
1890-91	113	122	126		120
1891-92	90	61	77	83	78
1892-93	124	117	110	146	124
1893-94	51	67	68	58	61
1894-95	132	155	152	123	140
1895-96	51	71	63	55	60
1896-97	105	121	145	110	120
1897-98	52	55	68	56	58
1898-99	47	54	42	37	45
1899-00	54	57	52	57	55
1900-01	109	84	87	104	96
1901-02	70	61	58	62	63
1902-03	110	112	105	111	110
1903-04	59	54	56	59	57
1904-05	130	156	136	113	134
1905-06	125	143	110	133	128
1906-07	146	154	145	140	146
1907-08	98	112	95	81	96
1908-09	109	113	96	118	109
1909-10	94	112	69	88	91
1910-11	103	101	92	117	103
1911-12	87	79	94		86
Number of years	42	31	23	20	
Observed mean	15.91	10.70	14.55	21.04	
Number of years	42	42	42	42	
Deduced mean	15.91	10.61	15.07	22.70	

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The distribution of precipitation through the year is shown by Table 12. There is a marked wet and dry season. The rainy months are December to March, inclusive, during which 77 per cent of the seasonal total occurs. The dryest months are June to September, when four per cent occurs, while April, May, October, and November intermediate with a total of 21 per cent. The ground water reservoir is therefore recharged during the spring months.

TABLE 12.

The monthly precipitation at San Bernardino Valley stations.

Month.	San Bernardino.		Riverside.		Redlands.		Upland.		Average of per cent
	Depth in inches.	Per cent of seasonal.	Depth in inches.	Per cent of seasonal.	Depth in inches.	Per cent of seasonal.	Depth in inches.	Per cent of seasonal.	
July	.08	1	.02	1	.04	1	.04	1	1
August	.17	1	.16	1	.31	2	.05	1	1
September	.17	1	.15	1	.34	2	.19	1	1
October	.60	4	.52	5	.66	5	.92	4	4
November	1.35	8	.77	7	.90	6	1.37	6	7
December	2.59	16	1.61	15	2.21	15	2.65	13	15
January	3.33	21	2.09	20	2.85	19	4.93	22	21
February	2.88	18	1.93	18	2.68	18	3.40	16	17
March	2.92	18	2.38	22	3.00	21	5.27	25	22
April	1.19	7	.69	6	.75	5	.99	5	6
May	.58	4	.34	3	.72	5	1.04	5	4
June	.08	1	.05	1	.11	1	.15	1	1
Totals	15.91	100	10.70	100	14.55	100	21.00	100	100

It is difficult to grasp the general tendencies of annual variation in precipitation from tables. A diagram has therefore been prepared (Fig. 2), showing the excess and deficiency of precipitation with respect to the mean at typical stations. The variation from the mean for each year is shown by small circles. The general tendency is shown by a heavy line obtained by averaging progressively the precipitation of each three consecutive years. This process smooths out the minor irregularities and shows broad variations clearly. Although the amount of precipitation differs, yet the variations from year to year agree exactly at the four stations, San Diego, San Bernardino, Riverside, and Los Angeles. Beginning with the season 1883-84 there began a period of the heaviest rainfall observed during the last sixty years, which continued until 1891–92. It was followed by the period of most severe drought ever recorded in southern California, which continued to 1903-04. There were, of course, individual years in each of these periods which departed from the general tendency, but these single years had little effect either upon run-off or ground water levels. Since 1903–04 there has been a period of marked increase followed by one of generally normal character.

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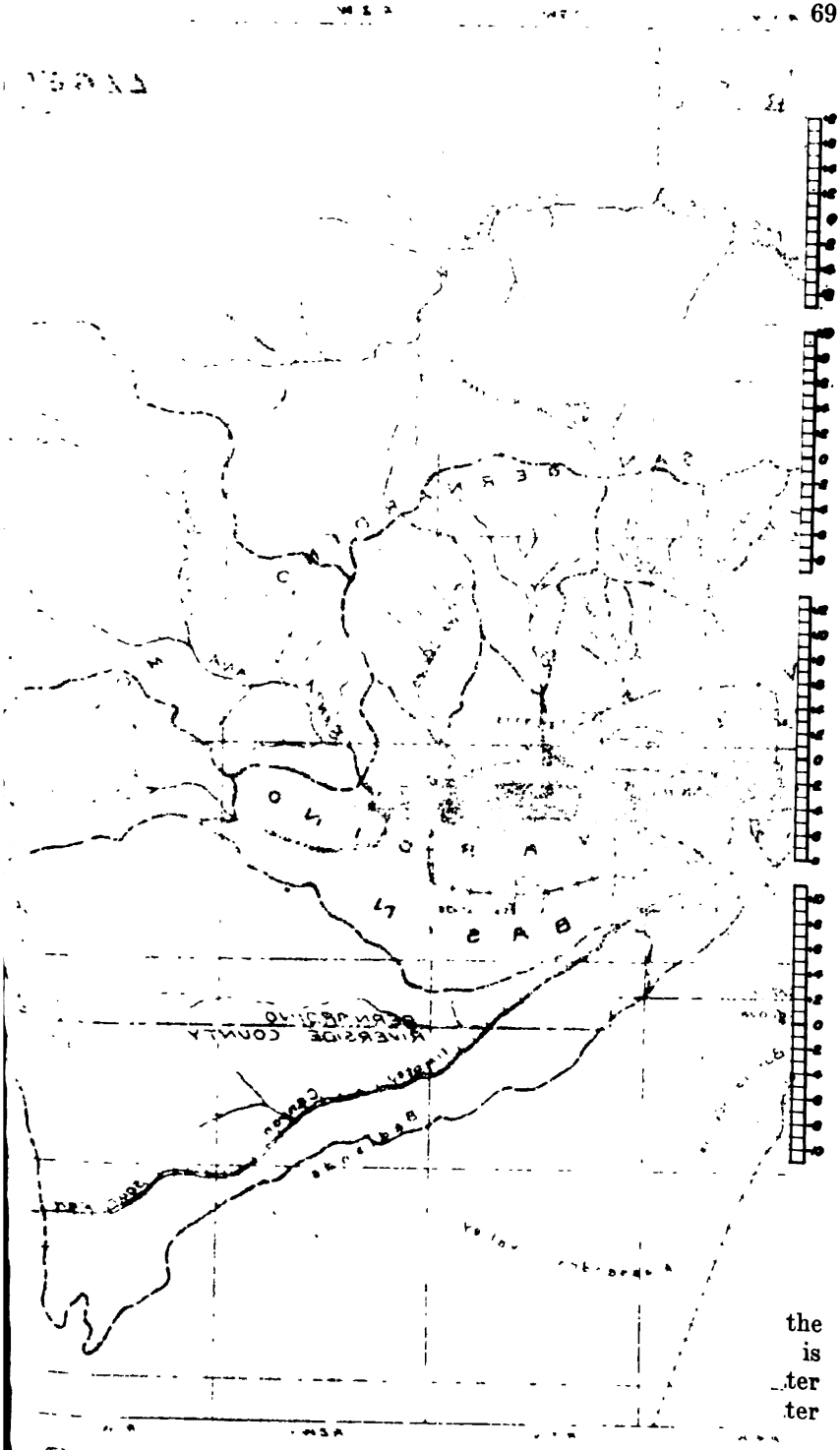

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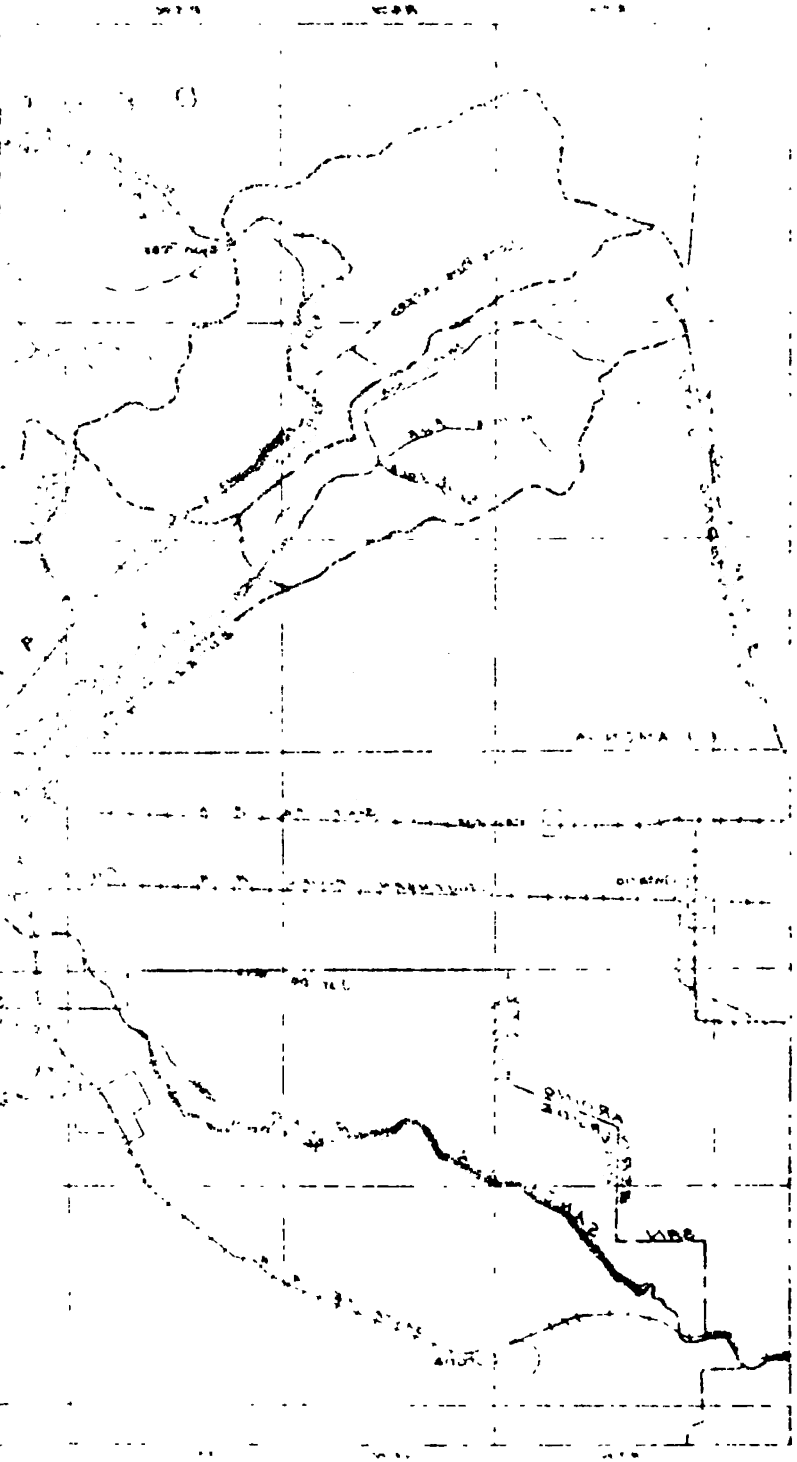

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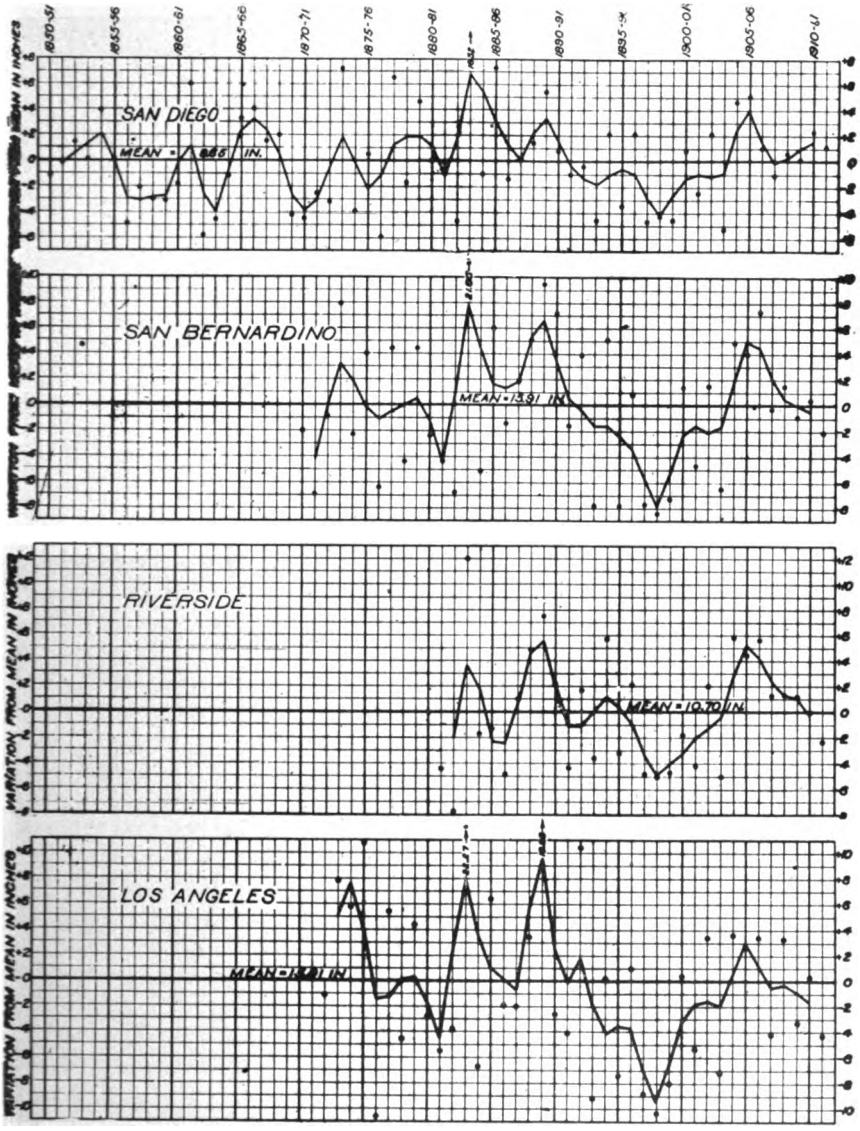

FIGURE-2-SEASONAL AND THREE YEAR PROGRESSIVE MEAN SEASONAL PRECIPITATION AT POINTS IN AND NEAR SAN BERNARDINO VALLEY.CALIFORNIA

Ground water levels do not rise and fall immediately with the seasonal variations in precipitation, since the effect of one year is carried on into the next by accretion or depletion of ground water storage. As long as annual rainfall is below normal ground water

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levels will fall. A period of normal rainfall would tend to arrest downward movement, but nothing short of a period of rainfall well above normal would bring about a complete reversal and recovery. The cause of fluctuations of ground water level can be shown best by a study of aggregate excesses and deficiencies of precipitation. A

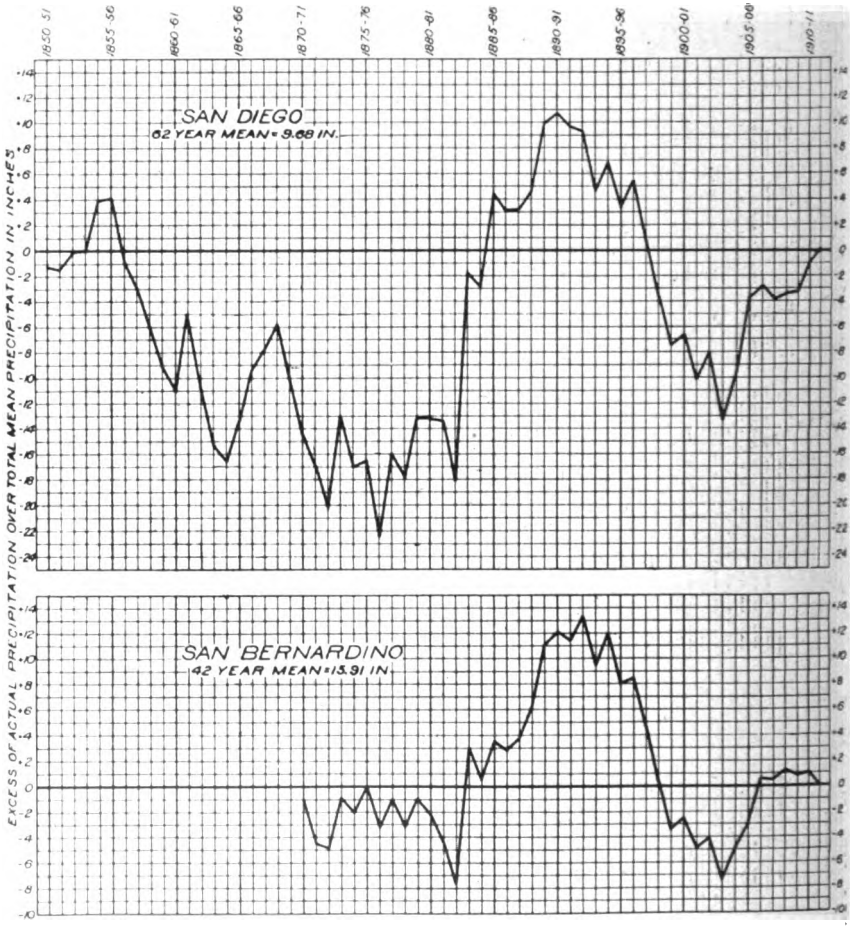
SAN DIEGO
62 YEAR MEAN=9.68 IN.
SAN BERNARDINO
42 YEAR MEAN=13.91 IN.
EXCESS OF ACTUAL PRECIPITATION OVER TOTAL MEAN PRECIPITATION IN INCHES

FIGURE-3-RESIDUAL MASS CURVES OF PRECIPITATION FOR TYPICAL SOUTHERN CALIFORNIA STATIONS

graph of such aggregates has the same general shape and tendencies as a graph of ground water fluctuations.[1]

Residual mass curves of precipitation have been prepared for two typical stations (Fig. 3). The ordinate of any point on these curves is the difference between the aggregate rainfall from the beginning of the period of record to the date considered, and the aggregate rain-

[1]Spear, W. E., Study of the Water Supply Sources of Long Island; Report of Commission and Additional Water-Supply of New York City, Appendix 7, 1903, pp. 753-and 817.

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fall which would have fallen during the same period if the annual rate was the observed mean. The diagrams show marked agreement in the general tendencies. There is the period of accumulation from the minimum of 1882–83 to the unprecedented maximum of 1891–92, followed by the period of rapid depletion ending in 1903–04. This was followed by a recovery to normal conditions during the period 1905 to 1907, which has been maintained down to present writing. The period of excessive drought 1891–92 to 1903–04 was, therefore, the necessary reaction from a period of several years unprecedented heavy rainfall, combined with a period of ordinary drought such as occurs in southern California at intervals of ten to fifteen years.

The severity of this drought has not been exceeded during any other similar period since 1850. It is therefore to be inferred that acting under natural causes ground water levels in 1892 were at a high stage, in 1904 and 1905 were at a very low level, and that there was a recovery to normal conditions in 1907 or soon thereafter. This conclusion is confirmed by well records.

Run-off.

The relative sizes and positions of the catchment areas tributary to the San Bernardino basin are shown on figure 1. Santa Ana River drains the largest area. It embraces 182 square miles above the government gaging station at Warm Springs Canyon and 208 square miles above the mouth of the canyon. Cajon Basin has an area of about 88 square miles, Lytle Creek 52 square miles, Mill Creek 46 square miles, City Creek 21 square miles, and Plunge Creek 17 square miles. The other canyons are small, none of them exceeding ten square miles in area. The total mountain drainage tributary to San Bernardino Valley is about 480 square miles. The San Timoteo Creek drainage is about 135 square miles. The valley lands above the dike have an area of about 132 square miles. The total area tributary to the drainage outlet of the basin at the Bunker Hill dike is about 750 square miles.

The Santa Ana drainage area discharges more water from its canyon than any of the others, but Mill and Lytle creeks have a greater run-off per square mile. The explanation for this is to be found in the precipitation exposures of the drainage areas. Mill and Lytle creeks both drain mountain faces receiving copious rainfall. The upper Santa Ana drainage, however, is on a high plateau which on the east borders the desert and receives a much smaller precipitation than the lower portion to the west which corresponds with Mill Creek in productiveness of run-off. The small drainage areas west of the Santa Ana reach moderate elevations and probably yield less run-off per square mile than Mill Creek, although their exposure is good. The run-off from Cajon Basin is very small on account of the low elevations, gentle slopes and desert exposure. The yield per square mile of Santa Ana Canyon is probably a good average for the 480 square miles of mountain drainage.[1]

[1] Lippincott, J. B., Water-Supply Paper No. 59, U. S. Geol. Survey, 1912, p. 53.

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TABLE 13.

Monthly and seasonal discharge in second-feet of Santa Ana River at mouth of cañon.

(Drainage area, 182 square miles).

Season.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	July.	August.	Year.
1896-97	69	71	37	39	68	185	124	150	76	80	83	75	88
1897-98	67	54	45	33	49	48	40	39	61	48	43	43	48
1898-99	38	26	22	22	26	27	32	25	22	22	22	13	25
1899-00	12	17	21	23	23	22	23	25	57	22	19	11	23
1900-01	12	14	107	28	78	194	68	43	42	37	38	50	59
1901-02	49	48	26	24	24	38	79	51	36	33	26	25	38
1902-03	24	40	24	22	33	48	148	352	92	64	51	55	79
1903-04	52	47	30	27	26	33	64	53	41	44	45	46	42
1904-05	50	48	20	20	37	98	130	90	172	78	63	67	73
1905-06	68	49	48	38	47	63	530	274	245	172	119	80	144
1906-07	64	71	60	111	239	292	681	552	236	171	135	90	225
1907-08	73	84	119	60	82	135	125	99	76	62	64	64	87
1908-09	59	58	43	43	120	238	183	209	158	97	69	64	112
1909-10	62	58	53	136	(760)	112	103	105	85	69	65	62	139
1910-11	65	61	47	44	128	197	431	213	130	104	89	61	131
1911-12	65	64	57	51	49	46	94	100	85	62	60	59	66
16-year mean	52	51	48	45	106	111	174	149	101	79	62	54	86

(Includes river at Warm Springs Cañon and canal.)

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TABLE 14.

Seasonal variation of run-off for Santa Ana River and precipitation at San Bernardino.

Season.	Discharge of Santa Ana River.			Precipitation at San Bernardino.	
	Mean second-feet.	Second-feet per square mile.	Per cent of 16 year average.	Depth in inches.	Per cent of 16 year average.
1896-97	88	0.48	102	16.74	112
1897-98	48	0.26	56	8.24	55
1898-99	25	0.15	29	7.49	50
1899-00	23	0.13	27	8.64	58
1900-01	59	0.32	69	17.36	116
1901-02	38	0.21	44	11.15	75
1902-03	79	0.43	92	17.42	117
1903-04	42	0.23	49	9.37	63
1904-05	73	0.40	85	20.78	139
1905-06	144	0.79	167	19.88	133
1906-07	225	1.24	262	23.17	155
1907-08	87	0.48	101	15.62	105
1908-09	112	0.62	130	17.36	117
1909-10	139	0.76	162	15.02	101
1910-11	131	0.72	152	16.34	110
1911-12	66	0.36	77	13.84	93
16-year mean	86	0.47	100	14.91	100

The Santa Ana is the only stream entering the valley upon which regular measurements have been made. The government has maintained a station at Warm Springs Canyon since 1896 for the purpose of observing flood flow and waste. During the irrigation season the river water is all diverted onto agricultural lands near Redlands and Highlands. The published government records include both flood flow and irrigation diversions so that the total run-off is available. There has been a storage reservoir operated in the interest of irrigation on Bear Creek, a tributary of the river, during the whole period of record. The maximum storage capacity has been 26,463 acre-feet up to the present season, when it was increased to 65,000 acre-feet. This partially regulates the monthly flow of the stream, but does not materially affect annual variations in run-off. The total mean seasonable flow of the stream for 16 years (1896–97) to date, is 86 second-feet or a continuous flow of 0.47 second-feet per square mile (Table 13).

The seasonal variations in run-off agree generally with the precipitation (Table 14). There are certain differences which may be noted however. Run-off extremes are much more intense than those of precipitation. A precipitation of 50 per cent of the normal produces a run-off of less than 30 per cent of normal, while precipitation 50 per cent above normal results in run-off $2\frac{1}{2}$ times the normal. A year of precipitation above the average following one or more considerably below is not accompanied by a similar increase in run-off. It is therefore to be expected that ground water levels near stream channels would accurately reflect variations in precipitation, although there

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would be a lag in the complete response of depleted ground water levels to increased precipitation.

The waters which are available to the Water Conservation Association for spreading over the porous gravels are the surplus flood flow of Santa Ana River and Mill Creek. The volume of flood waste from Santa Ana River can be computed with fair accuracy, but no records of discharge are available for Mill Creek. For the purpose of making an estimate of the flood flow from Mill Creek it has been assumed that the run-off per square mile from the drainage area of 46 square miles is 0.60 second-feet continuous flow. This is fully justified by local knowledge of the two streams as well as the government records for San Gabriel River, which show a mean yield of between 0.60 and 0.70 second-feet per square mile for that stream. On this basis the total run-off of Mill Creek is one third of that of Santa Ana River. The use of water diverted for irrigation is similar for the two streams. The proportion of flood waste is possibly greater from Mill Creek than from Santa Ana River because of absence of storage regulation on the former stream. The use of the same percentages of flood waste to total run-off for Mill Creek as determined for Santa Ana River will therefore give conservative results for flood waste. This was the basis for computations.

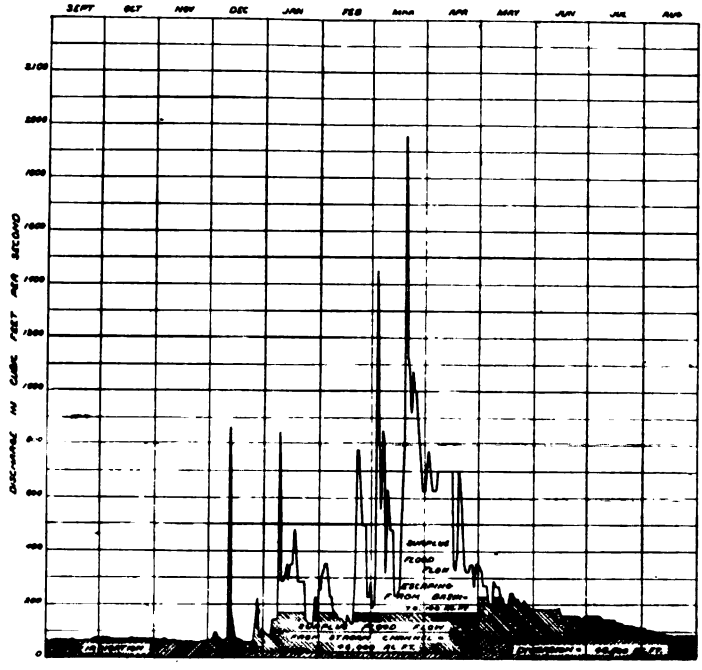

FIGURE 4 HYDROGRAPH OF DAILY DISCHARGE OF SANTA ANA RIVER FOR SEASON 1906 - 1907.

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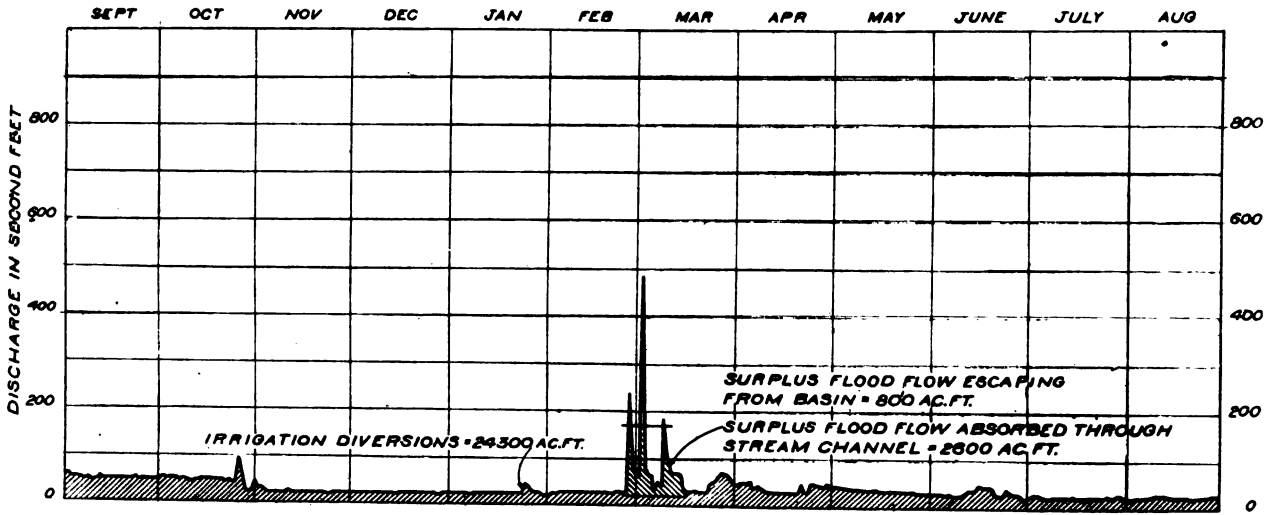

FIGURE-5-HYDROGRAPH OF DAILY DISCHARGE OF SANTA ANA RIVER FOR SEASON 1901-02

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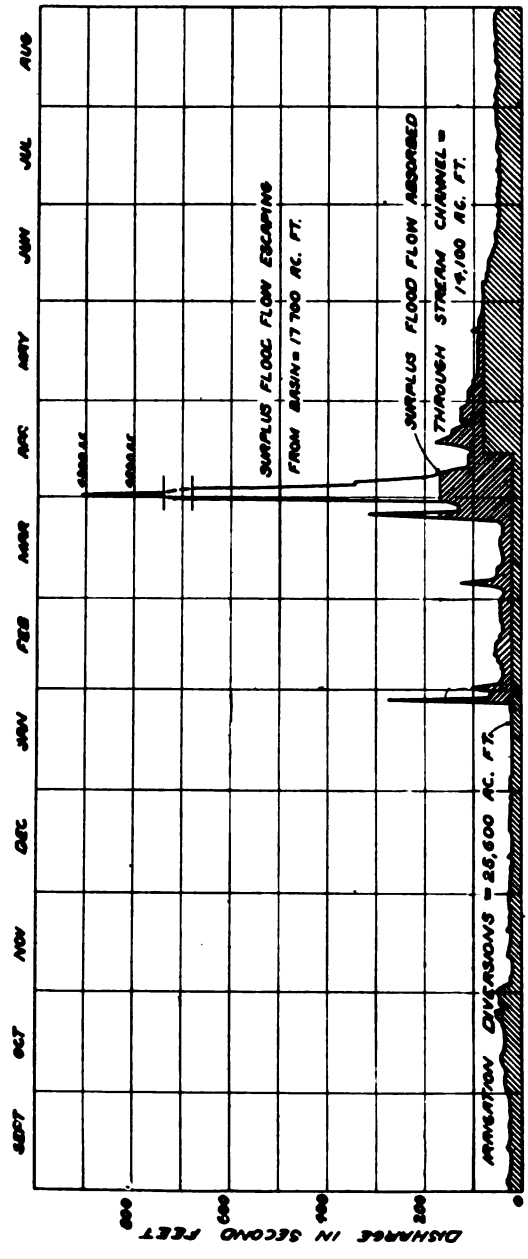

FIGURE-6-HYDROGRAPH OF DAILY DISCHARGE OF SANTA ANA RIVER FOR SEASON 1902-03

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TABLE 15.

Volume of surplus flood water from Santa Ana River and Mill Creek available for water spreading.

Season September 1 to August 31.	Run-off, Santa Ana River at Warm Springs, acre-feet.			Computed run-off, Mill Creek,* acre-feet.			Total surplus available for water spreading.
	Total.	Surplus.	Per cent surplus of total.	Total.	Surplus.	Per cent surplus of total.	
1900-01	42,200	15,600	37	13,900	5,200	37	20,800
1901-02	27,700	3,400	12	9,200	1,100	12	4,600
1902-03	57,400	31,800	56	18,900	10,500	56	42,300
1903-04	30,700	1,500	5	10,200	500	5	2,000
1904-05	52,600	18,600	35	17,400	6,100	35	24,700
1905-06	105,100	66,100	63	34,700	21,800	63	87,900
1906-07	162,600	116,100	71	53,600	38,300	71	154,400
1907-08	62,800	21,400	34	20,800	7,000	34	28,400
1908-09	80,200	43,100	54	26,400	14,200	54	57,300
1909-10	101,200	63,600	63	33,400	21,000	63	84,600
1910-11	94,400	56,100	60	31,100	18,500	60	74,600
1911-12	51,100	9,000	18	16,800	3,000	18	12,000
Mean	72,100	37,200	42	23,700	12,300		49,500

*Total run-off Mill Creek assumed 33 per cent of that for Santa Ana River.

The computation of surplus flood flow from Santa Ana River was based on a daily hydrograph of the total flow of the stream at the mouth of the canyon from January 1, 1900, to October 1, 1912. Three typical seasons from this hydrograph are presented on figures 4, 5 and 6, the season of 1906–07 being one of unusually large run-off, 1901–02 considerably below normal, and 1902–03 very slightly below normal (Table 14). These diagrams show strikingly the extreme fluctuations of both annual and monthly flow, which characterize the stream even with the existing storage regulation. The irrigation diversions made by the Redlands and Highland canals at the mouth of Santa Ana Canyon are based on approximate estimates, since the records of the Bear Valley Mutual Water Company were not available. The maximum capacity of the two canals is stated by the manager of the company to be 100 second-feet, but this amount is seldom carried. For purposes of computation it was assumed that from the opening of the irrigation season, which varies from April 1st to May 1st to the first general storm in November or December, the combined diversion would be 80 second-feet, except when the discharge of the river was less than this amount, at which time the full flow would be diverted. During the winter season the combined diversion was assumed to be 20 second-feet. The date of opening of the irrigation season was assumed as April 1st in years of light spring rains, April 15th in years of normal spring rains, and May 1st in wet years. The diversions are indicated on the diagrams. The portion of the area within the total discharge line and above the line of irrigation diversion represents surplus flood flow which passes down the Santa Ana Wash, and is available for water spreading. The amounts in acre-feet were computed for each season

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and are presented together with the total run-off of the stream and the per cent of surplus in the first part of table 15. Considering the period as a whole, 42 per cent of the run-off of Santa Ana River was surplus flood flow which passed the irrigation canal intakes. The per cent in individual seasons varied from 5 to 71. The average annual amount for the period was 37,200 acre-feet, the minimum 1,500 acre-feet, and the maximum 116,100 acre-feet. Adding to these values the waste from Mill Creek, the average annual amount of water available for water spreading is 49,500 acre-feet, the minimum 2,000 acre-feet, and the maximum 154,400 acre-feet.

The extent to which the existing spreading system has been able to handle the available water is shown by the fact that for the last two years the average amount diverted was about 12,000 acre-feet, or 24 per cent of the average amount available. The limit of the system is the amount which can be diverted in a season like 1906–07. The flood flow period covered about 120 days that season. Eliminating the days when the river water would be too heavily charged with silt to admit into the ditches, there would remain approximately a 100-day actual working season. With an average diversion during this period of 150 second-feet the total amount spread would be 30,000 acre-feet. The minimum annual diversion is the amount available in a season like 1903–04, or 2,000 acre-feet. The system as now laid out and operated is therefore able to handle about 20 per cent of the surplus flood flow in years of excessive run-off, 43 per cent in years of average run-off such as 1907–08, and 100 per cent in years of extreme drought. Although good progress has been made toward conservation of flood waters, yet the larger floods which have great possibilities as sources of water for over-year storage still remain practically untouched. The storage of a greater proportion of such flood water should be the aim of the future work of the association.

Stream percolation.

The limited time available for the investigations made it impossible to obtain field measurements of percolation from natural channels. The importance of having data upon this subject is obvious, since without it no comparison can be made of the relative efficiency of natural and artificial percolation, nor can the volume of flood water be computed, which passes from the San Bernardino Basin to the ocean.

The most complete study of natural stream percolation upon streams of the same general type as those under consideration is that carried on by the Los Angeles aqueduct in Owens Valley, California.[1] Comparative current meter measurements were made at intervals of four to six weeks for eighteen months, on twelve mountain streams. The channel traversed the alluvial slope between mouth of canyon and upper edge of valley floor and varied from three to seven miles in length. The gravels were probably not as open and porous as those of southern

[1] Lee, Charles E., Water-Supply Paper No. 294, U. S. Geol. Survey, 1912.

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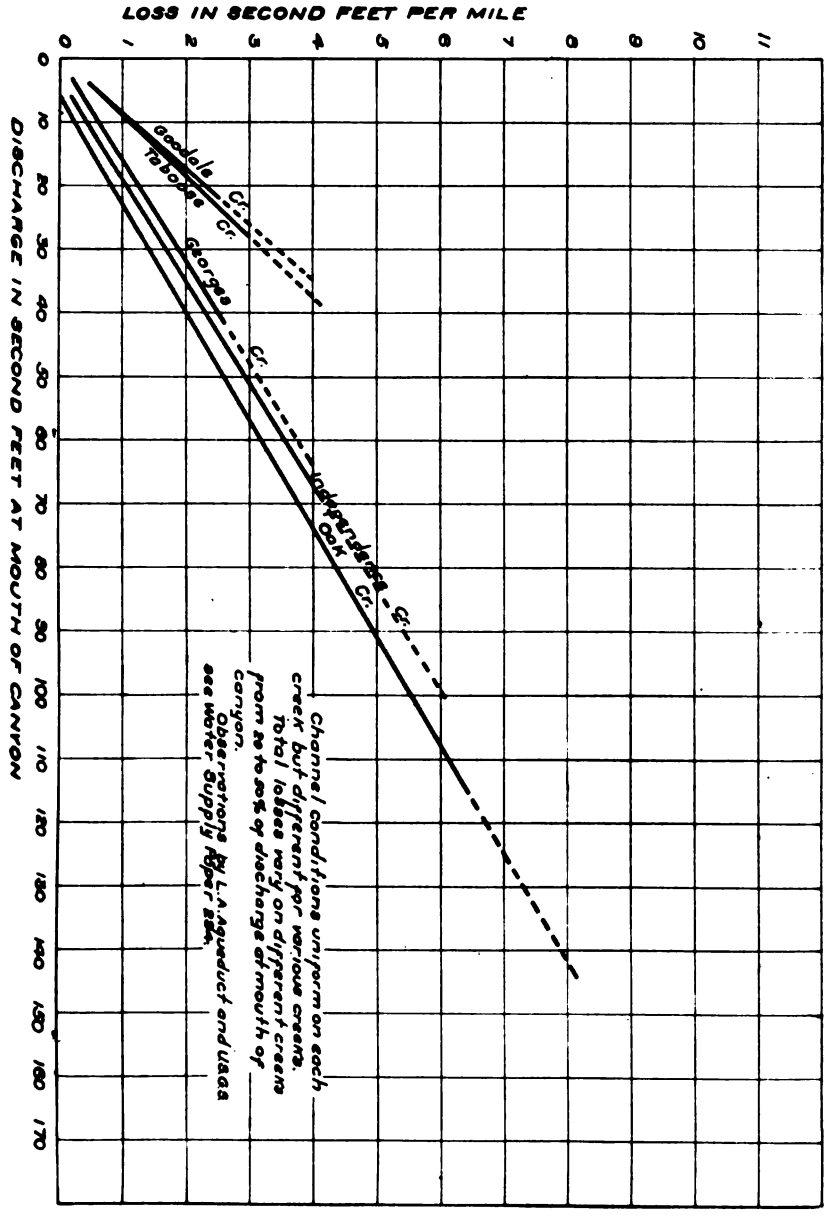
LOSS IN SECOND FEET PER MILE
0 1 2 3 4 5 6 7 8 9 10 11
DISCHARGE IN SECOND FEET AT MOUTH OF CANYON
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170
Goodale Cr.
Taboose Cr.
George Cr.
Independence Oak Cr.
Channel conditions uniform on each creek but different for various creeks. Total losses vary on different creeks from 20 to 80% of discharge at mouth of canyon.
Observations by L.A. Aqueduct and U.S.G.S. see Water Supply Paper 338.

FIG. 7. Stream percolation diagram for Owens Valley creeks.

California and the channels were sufficiently deep and firm to carry flood flows. Careful graphical study of the data showed that for each channel a definite straight line relation existed between total discharge and total percolation loss, or loss per mile of channel. The relations

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differed for different streams depending upon the formation and the type of channel, but the general law was uniformly observed. Curves for five typical streams are shown on figure 7.

The only available measurements of stream percolation in southern California are those made by the Water Resources Branch of the United States Geological Survey in the spring of 1903.[1] These were made upon twelve streams flowing from the San Gabriel and San Bernardino Mountains during and after the moderate floods of April 16th. There were but two sets of measurements on most of these streams, but straight line curves constructed from these appear reasonable and give results consistent with the Owens Valley data (Fig. 8). The losses per mile of channel are approximately twice those observed in Owens Valley. This is to be expected, however, because of more open gravels traversed by the southern California streams and the tendency of flood water to spread out in a broad sheet. There were observations made on a few of the southern California streams which showed that the rate of loss per mile was greater for that portion of the channel low down on the slope where velocity was checked and the material was predominantly coarse sand. The data was not sufficient to show this variation, however, and in interpreting the diagrams the loss per mile should be recognized as an average.

The results for Santa Ana River are of value in connection with water spreading work. On April 24th a stream of 150 second-feet at the junction of Mill Creek was entirely absorbed before it reached the head of the Gage Canal, a distance of about eight miles. On May 16th a stream of 67 second-feet shrank to 30 second-feet by the time it reached Orange street, and entirely disappeared in the next half mile. The Riverside Trust Company diverted and spread the stream below Orange street bridge, however, so that natural percolation occurred only between Mill Creek junction and Orange street. The curve constructed from this data, although showing slightly less loss per mile than that for Pacoima Creek, is yet parallel to that curve and appears consistent with the other curves and entirely reasonable. It is stated by Mr. J. M. Mylne, engineer for the Riverside Trust Company, that immediately following a flood crest a discharge of 200 second-feet at the junction of Mill Creek will ordinarily disappear before reaching the head of the Gage Canal, but that later on when the stream has cut a narrow channel for itself a discharge of only 100 second-feet would be thus absorbed. Estimates based on an average loss of 150 second-feet would, therefore, be conservative.

A computation of the volume of surplus water absorbed by the gravels and also that passing immediately from the basin was made for Santa Ana River. It was based upon the daily hydrograph of the stream and a maximum percolation loss of 150 second-feet from surplus water following the Santa Ana Wash between the junction of Mill Creek and the head of the Gage Canal (Table 16). An estimate was also made of similar values for Mill Creek. The results indicate that as an average

[1]Hoyt, John C., Water-Supply Paper No. 100, U. S. Geol. Survey, 1904, pp. 339-354.

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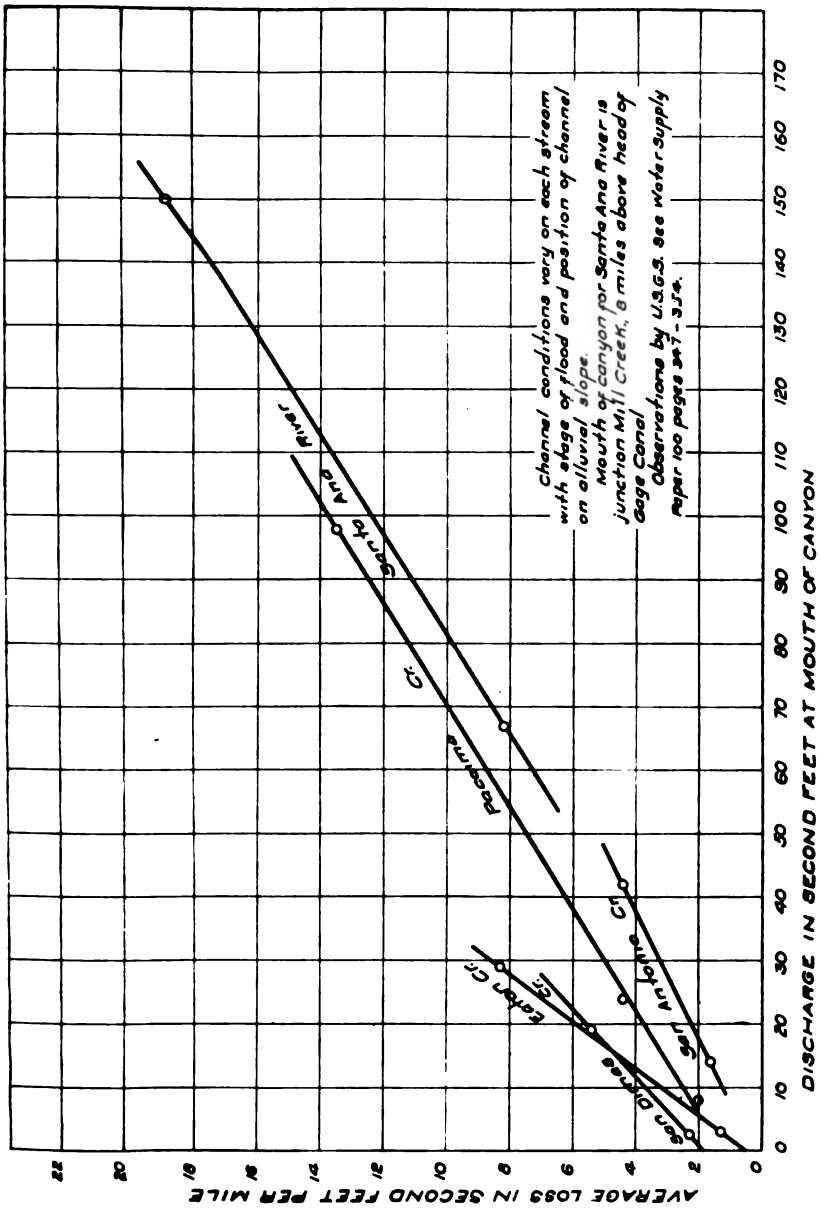

Fig. 8. Stream percolation diagram for southern California streams.

26,500 acre-feet or 54 per cent of combined surplus flood waters from Santa Ana River and Mill Creek cross the Bunker Hill dike immediately, and are lost from the basin. In the wet season 1906–07, 70 per cent was lost and in 1903–04 practically no water escaped from the basin.

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TABLE 16.

Disposition of surplus flood water from Santa Ana River and Mill Creek without artificial control through water spreading.

Season September 1 to August 31.	Total surplus passing junction Mill Creek, acre-feet.	Disposition of Santa Ana surplus, acre-feet.		Disposition of Mill Creek surplus, acre-feet.		Total loss from basin, acre-feet.
		Percolation into gravels.	Lost from basin.	Percolation into gravels.	Lost from basin.	
1900-01	20,800	11,100	4,500	4,200	1,000	5,600
1901-02	4,600	2,600	800	1,000	100	900
1902-03	42,300	14,100	17,700	5,300	5,200	23,000
1903-04	2,000	1,500	----------	500	----------	----------
1904-05	24,700	17,500	1,100	4,600	1,500	2,600
1905-06	87,900	32,000	34,100	----------	21,800	55,900
1906-07	154,400	46,000	70,100	----------	38,300	108,400
1907-08	28,400	20,700	700	3,500	3,500	4,300
1908-09	57,300	32,200	10,900	3,500	10,700	21,600
1909-10	84,600	25,800	37,800	5,200	15,800	53,500
1910-11	74,600	32,900	23,200	----------	18,500	41,700
1911-12	12,000	8,400	600	2,700	300	900
Mean	49,500	20,400	16,800	2,600	9,700	26,500

With the present water spreading system in operation, the average amount lost from the basin will be reduced from 54 to 30 per cent of the combined surplus from the two streams, and the maximum loss from 70 to 50 per cent. In years of drought nearly the whole flow of the stream is absorbed by natural percolation and the only advantage of water spreading would be to get the water into the gravels of the upper slope, and thus store it for use at some future year instead of during the current year. The greatest benefit will result from artificial ground water storage when its primary aim is annual storage regulation. Very effective work has been accomplished already, but still greater possibilities remain.

GROUND WATER FLUCTUATIONS.

Changes in rate of ground water supply corresponding to variation in precipitation and run-off result in vertical movements of free ground water surface, and variation in artesian pressure. The first of these effects can be measured by observing the rise and fall of water in wells. The variation in artesian pressure can best be measured directly by placing pressure gages on capped wells. This, however, has never been done in the San Bernardino Valley. Another method is by determination of the artesian boundary and measurement of the flow from artesian wells. The flow of springs and seepages and the extent of swampy or moist land overlying the artesian basin furnish confirmatory evidence. The volume of ground water returning to the surface and flowing from the basin by way of Santa Ana River and Warm Creek would give still further knowledge. The data presented consist of measurements of free ground water level in wells outside the region of shallow artesian pressure, the artesian boundary at various times, the flow of a few artesian wells, and general information regarding springs and swamp conditions.

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Ground water levels.

The most complete data regarding ground water levels in San Bernardino Valley are the measurements of depth to water made by the United States Geological Survey in a series of about 75 wells in San Bernardino and Redlands quadrangles. These wells were selected by Mendenhall[1] in 1904 from among those measured by J. B. Lippincott[2] in 1900. and were observed under the former's direction at intervals of a year or two until 1909. They were observed again in 1912 for the purposes of this study (Tables 17 and 18). Observations were made during the latter part of October each year when ground water levels are the lowest and pumping has practically ceased (Table 19). The wells are distributed throughout the basin and thus eliminate the possibility of drawing mistaken conclusions from local conditions (Plate I).

[1]Mendenhall, W. C., Water Supply Paper No. 142, U. S. Geol. Survey, 1905, pp. 57 and 58.
[2]Lippincott, J. B., Water Supply Paper No. 60, U. S. Geol. Survey, 1902, pp. 115-134.

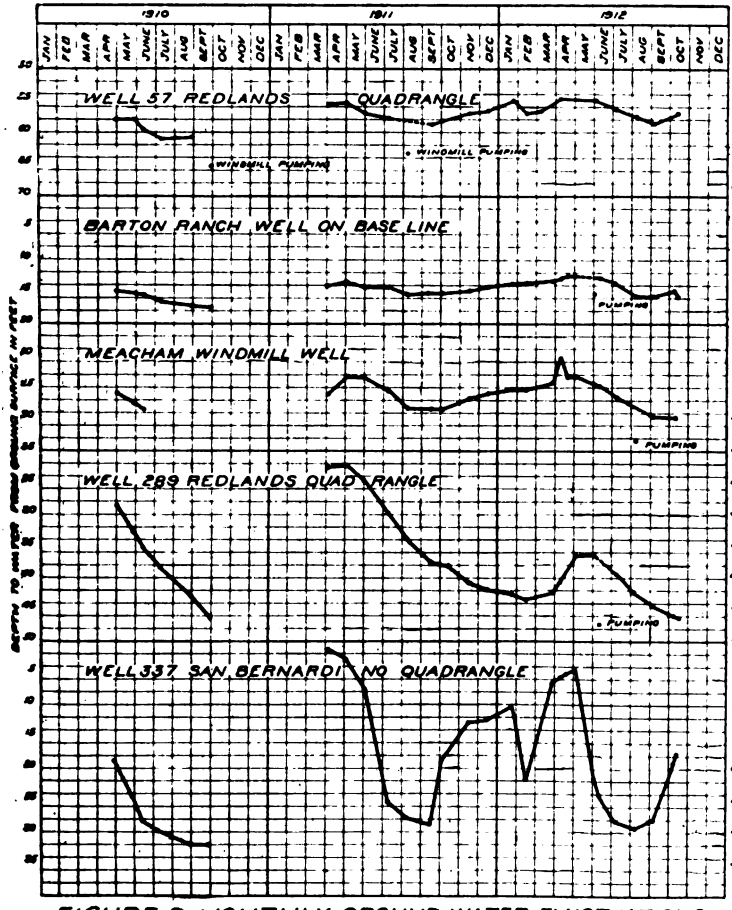

FIGURE-9 MONTHLY GROUND WATER FLUCTUATIONS IN TYPICAL WELLS IN SAN BERNARDINO VALLEY

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TABLE 17.

Depth of water surface in wells in Redlands quadrangle.

Years 1900 to 1912.

No. of well.	Owner.	Elevation of surface feet.	Depth to water in feet.					
			1900, October.	1904, October.	1906, October.	1907, August 30	1909, October 15-17.	1912, October 16-18.
1	Dr. Mecker	1,996	278	281(dry)	(dry)			
2	Ward, Mills & Co.	2,005	72	50	28.5			46.6
5	R. P. McIntosh	2,250	25	27				21.0
7	R. P. McIntosh	1,910	92	78	57.0		66.3	71.5
9	L. Lyons	2,075	23	13	14.0		4.3	[2]14.4
14	W. J. Tench	1,720	160	164	139.0		126.2	
28	Garland Estate	1,570	176				200	249.7
42	C. L. Hayes	1,420	150	180(dry)				129.3
43	O. W. Harris	1,503	200	203(dry)	89.1		218.8	
45	A. C. Fowler	1,250	110	170(dry)	sealed		120.9	96.4
46	L. C. Smith	1,215	80	90(dry)	116.7			62.8
48	E. Vache	1,260	60	78	78.2		81.8	67.3
56	H. Bermudas	1,210	54	23	77.8		65.6	57.0
60	R. T. Curtis	1,123	50	68	70.2	65.8	57.2	49.1
66	Gansnor & Renwick	1,140	30	55	[1]64.0		44.4	37.0
80	Mrs. S. W. Sylvera	1,200	30	63	50.5	45.2	44.2	39.0
83	S. Mansfield	1,193	39	50	47.8	43.8	40.4	31.7
84	A. Lenanon	1,186	30	55	53.0	46.3	42.5	34.6
94	W. A. Nichols	1,246	54	70	54.0		50.4	38.5
102	Willis Miller	1,290	87	103	91.6		77.7	69.3
109	C. A. Shaw	1,267	50	82	74.5	67.2	58.5	41.1
113	A. Gregory	1,245	51	70	65.2	60.2	51.0	38.0
117	S. Ronzone	1,257	65	91	74.0	64.0	62.8	56.6
120	M. R. Gay	1,220	50	75	58.0	54.7	sealed	[3]54.8
123	J. F. Boyd	1,290	110	110	90.0		77.5	70.0
124	Wm. Lindenberg	1,220	40	65	57.0	50.4	42.7	34.2
125	H. S. Drew	1,167	34	30			36.0	
126	James Smith	1,164	34	51			44.2	33.7
130	Clark & Brotherton	1,195	33	48				pumping
131	J. J. Prendergast	1,200	34	41				pumping

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132	H. H. Cole	1,140	32	45	47.0	----	35.8	32.9
139	H. R. Scott	1,120	12	20(dry)	----	----	24.0	----
145	E. F. Van Leuven	1,103	20	33	26.0	----	20.6	[2]25.7
155	F. Morris	1,260	65	95	96.3	----	84.1	76.1
289	—— Slack	1,227	67	93	----	----	47.5	46.1
290	Pattee & Nye	1,200	50	74	----	30.5	43.5	43.2
291	H. B. Robertson	1,180	53	70	42.5	32.8	38.2	37.5
292	L. H. Williams	1,160	40	55	----	----	----	[4]23.5
343	Haws & McKinley	1,125	----	10	4.0	----	----	3.0
350	Jane C. Goodman	1,140	12	32	20.7	16.5	16.0	10.1
386	California State Hospital	1,110	32	46	filled	----	filled	filled

[1]July 15 reported.
[2]Well 8, 30 feet east being pumped.
[3]Windmill pumping slowly.
[4]Observed in 6-inch casing well, 400 feet south of 292, approximate same elevation.
[5]Observed in well 200 feet deep, 600 feet south of well 120.

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TABLE 18.

Depth to water in wells in San Bernardino quadrangle.
Years 1900 to 1912.

No. of well.	Owner.	Elevation of surface, feet.	Depth to water in feet.					
			1900. October.	1904. October.	1906. October.	1907. August 30.	1909. October 15-17.	1912. October 16-18.
73	W. L. Zader	980	50	60	61.2	----------	57.8	----------
76	Mrs. B. R. Atkins	980	42	57	57.0	----------	46.7	----------
78	W. D. Sores	875	4	12	12.5	----------	11.2	----------
104	Riverside Trust Company	1,077	flowing	5	4	----------	flowing	flowing
178	G. W. Curtis	1,088	25	43	37.0	----------	30.8	----------
181	W. A. Thomas	1,078	2	10	31.4	----------	8	----------
189	E. M. Cooley	1,019	60	42	45.3	----------	47.5	----------
199	Washington School	1,043	77	82	77.6	----------	76.1	----------
201	Fred Pooles	955	48	60	56.4	----------	56.0	----------
277	G. Renwick	1,090	35	40	----------	----------	22.8	16
280	E. Memory	982	55	62	----------	----------	----------	(53)
282	C. H. Westmyer	1,069	7	21	sealed	----------	sealed	sealed
316	Geo. M. Cooley	1,150	42	60	61	----------	----------	40
317	Geo. M. Cooley	1,150	42	60	61	----------	----------	pumping
317½	Geo. M. Cooley	1,150	42	60	61	----------	----------	pumping
318	E. J. Stiles	1,196	39	50	48.5	35.8	----------	33
319	James Dickson	1,179	34	48	----------	----------	----------	30
329	M. S. Severance	1,288	145	173	sealed	sealed	----------	[1]148
341	H. N. Stones	1,141	54	63	70.5	49.7	----------	40
354	S. F. Kelley	1,170	49	75	77.7	62.8	48.0	36
357	S. H. Johnson	1,182	60	100	89.3	pumping	60.5	49
364	F. Alvarado	1,188	53	70	78.2	54.8	47.4	[2]42
367	D. W. White	1,109	20	35	sealed	sealed	20.5	pumping
370	F. L. Holcomb	1,128	28	50	43 (dry)	43 (dry)	34.0(dry)	filled
375	Dexter Field	1,147	35	58	65 (dry)	55.2(dry)	35.1	24
389	S. E. A. Palmer	1,176	52	77	85.5	70.4	46.9	[3]35
398	N. M. Swarthout	1,142	27	48	55.6	46.8	28.7	[3]19
400	J. H. Lytle	1,166	31	80	73.6	60.4	40.8	29
416	H. H. Ham	1,121	31	46	55.1	46.3	filled	filled

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445	A. W. Bemis	1,114	10	[4]87			[4]13.0	[4]9
450	S. A. Jackson	1,116	22	40	50.5	41.2	23.7	16
457	J. F. Cadd	1,068	11	16	26.2	16.5	filled	filled
458	H. E. Gardner	1,089	10	26	sealed	sealed	sealed	sealed
470	Chas. Morris	1,078	15	24	20	filled	filled	filled

[1]Observed depth in well of W. R. Severance, 500 feet east, approximate same elevation.

[2]Observed depth in well 393, 500 feet west.

[3]Windmill pumping.

[4]Observed depth in well 444, 500 feet northwest and subtracted 4 feet—difference of surface elevation.

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TABLE 19.

Monthly variation in groundwater level for five wells in San Bernardino Valley.

Date.	Depth to water in feet. Well 57, Redlands quadrangle.	Well 289, Redlands quadrangle.	Well at Barton ranch on base line.	Well 337, San Bernardino quadrangle.	Meacham wind mill well, Section 35, T. 1 N., R. 4 W.
1910—	[1]	[2]	[2]	[1]	[1]
April 28	58.08	28.60	14.95	18.86	26.00
May 26	58.00	32.92	15.25	24.50	27.50
June 11	59.50	35.25	15.58	28.20	28.50
July 9	61.00	38.32	16.60	29.90	----------
August 27	60.80	42.89	17.20	31.95	----------
September 28	65.30	46.30	17.50	32.04	----------
1911—					
April 4	55.55	22.60	14.03	1.27	26.00
May 2	55.25	22.02	13.40	2.98	23.30
June 1	57.00	24.55	14.20	7.65	23.48
July 8	57.82	29.80	14.20	25.25	[5]25.55
August 8	[5]63.20	33.75	15.42	27.85	[5]28.20
September 14	58.70	37.35	15.09	28.90	28.30
October 3	58.10	38.03	15.10	18.70	28.20
November 14	57.00	40.75	14.88	12.81	26.84
December 14	56.60	41.80	14.11	12.31	26.00
1912—					
January 23	55.00	42.50	13.70	10.18	25.35
February 15	57.00	43.20	13.59	21.75	25.35
March 7	56.70	----------	----------	----------	----------
March 26	----------	42.09	13.07	6.60	24.16
April 9	54.78	40.60	12.90	5.84	19.30
April 19	----------	----------	12.52	5.10	23.30
May 3	----------	36.53	12.52	4.54	[5]23.30
June 3	55.06	36.31	15.09	21.46	[5]24.69
June 10	----------	[4]47.10	12.86	24.10	[5]24.80
July 6	56.40	39.25	13.65	28.07	26.50
August 7	57.40	42.05	15.65	29.15	[5]33.20
September 5	58.60	44.18	15.60	28.00	29.62
October 9	----------	----------	14.90	19.08	29.80
October 12	57.00	45.95	15.83	17.64	29.80
October 16	----------	46.10	----------	----------	----------

Observations by Riverside Water Company.
[1]Top of casing to water surface.
[2]Top of lagging to water surface.
[3]Top of blocks to water surface.
[4]Pumping.
[5]Windmill pumping.
Well 337 on June 9, 1908, 33.60.
Meacham windmill well on June 9, 1908, 34.35.

Many of these wells are 7-inch casing windmill wells of moderate depth. Such wells are more reliable for making observations since they are not as liable to experience the wide artificial fluctuation which occur in deep pumped or artesian wells. They are slow to register ground water fluctuations when situated far from some stream channel which is a source of percolating water, but they no less surely experience these fluctations. These conditions are well shown from monthly observations of ground water level made by the Riverside Water Company during the last three years in four wells east of San Bernardino, and

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one well near Redlands Junction (Table 19 and Fig. 9). Well 57 in the Redlands quadrangle and the Barton and Meacham domestic well are shallow. Well 289 Redlands quadrangle is a deep casing well equipped with centrifugal pump. Well 337 San Bernardino quadrangle is an old artesian well reported to be 325 feet deep, which reaches one or more of the artesian strata drawn upon by the large artesian wells along Base Line, Ninth and Sixth streets, east of San Bernardino. The shallow wells have a range of annual fluctuation of from two to six feet with the lowest level in September or October. The pumped well has a fluctuation of from 10 to 25 feet with a minimum just preceding the first general winter storm. The old artesian well has an annual fluctuation of from 25 to 30 feet. The record on this well is of particular value since it shows the marked effect produced upon artesian pressure by opening a number of the large flowing wells. The result is shown in this well by an immediate lowering in water levels of from 15 to 20 feet. The owner of the well states that he has observed the level drop in this manner within an hour of the opening of large wells along Sixth street. Partial recovery at the time flowing wells are capped is equally rapid, but full recovery is delayed until the basin is recharged from winter rains. Similar conditions are reported in many other wells around the rim of the artesian area. These records show the greater reliability of wells which do not reach artesian strata for determinating annual tendencies in ground water fluctuations.

The government records in Tables 17 and 18 show that ground water levels fell materially throughout the basin from 1900 to 1904. Wells situated away from stream channels continued to fall until 1906, but those near stream channels showed partial recovery in that year. In 1907 all observed wells showed recovery. The observations of 1909 showed still further recovery, and in 1912 the levels in many wells were higher than in 1900. The average rise of ground water levels throughout the basin from the lowest levels of 1904 or 1906 to the level of 1912, is 30 feet. Some of the most marked recoveries were in the region north and northwest of San Bernardino; for example, the rise in Well 354 was 42 feet and in Well 389, 50 feet. This region on account of its relative position can not have received a greater benefit from water spreading than any other, and it is doubtful if it benefits even by increased deep artesian pressure. The total amount of water spread by the association during the last four seasons has not exceeded 30,000 acre-feet, a volume of water which would represent about 90,000 acre-feet of saturated gravels, or three feet depth over 47 square miles. Within that four-year period water levels had risen at least 15 feet over a larger area and had commenced to rise rapidly even before water spreading was practiced extensively. The conclusion is that water spreading has had comparatively little to do with the general recovery of ground water levels in the San Bernardino Valley.

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TABLE 20.

Discharge of Artesian Wells in San Bernardino Valley.

In miner's inches.

McCrary Tract wells.		Cooley wells, Ninth street, San Bernardino.		Heap wells, Ninth street, San Bernardino.		Kats-Walkinshaw wells.	
Date.	Discharge.	Date.	Discharge.	Date.	Discharge.	Date.	Discharge.
1898.							
Apr. 16	292.7						
July 26	315.4						
Aug. 26	315.8						
Sept. 6	340.6						
Sept. 25	357.8						
Oct. 2	349.4						
1899						1899.	
July 12	310.0					July 29	100.2
July 25	296.3					Aug. 1	97.6
Aug. 8	281.0					Aug. 8	102.0
Sept. 26	265.2					Aug. 25	116.2
Oct. 19	272.0					Sept. 26	114.5
						Sept. 30	116.2
1900.						1900.	
Mar. 15	258.6					Aug. 10	112.3
June 19	245.9						
July 19	215.7						
Aug. 6	220.8						
Sept. 6	203.0						
Oct. 3	193.4						
1901.						1901.	
Mar. 28	203.0					May 14	112.4
June 4	184.0					May 28	112.4
June 18	147.3					June 28	104.8
July 8	197.6					July 24	97.2
July 19	192.5					Aug. 31	82.4
Aug. 1	188.7					Sept. 28	73.5
Aug. 31	180.2						
Sept. 12	172.8						
Sept. 28	172.3						
1902.		1902.		1902.		1902.	
Jan. 8	168.3	May 22	73.0	July 12	110.0	July 1	90.5
Mar. 12	165.7	July 12	65.0	July 21	110.0	Aug. 1	75.0
Apr. 30	157.9	Aug. 12	62.0	Aug. 12	110.0	Sept. 1	89.0
May 24	154.8	Aug. 26	58.9	Aug. 26	110.0	Oct. 1	80.0
June 12	150.3	Oct. 13	57.8	Oct. 13	110.0		
July 12	138.3	Oct. 21	63.2	Oct. 21	101.8		
July 21	137.4						
Aug. 12	135.9						
Aug. 26	129.7						
Sept. 30	129.7						
1903.		1903.		1903.		1903.	
May 22	157.8	Not measured.		May 19	110.0	Not measured.	
July 13	140.6			July 20	101.8		
Aug. 4	138.8			Aug. 4	101.8		
Sept. 1	132.0			Sept. 2	102.0		
Oct. 27	125.1			Nov. 27	102.0		

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TABLE 20—Continued.

Discharge of Artesian Wells in San Bernardino Valley.

In miner's inches.

McCrary Tract wells.		Cooley wells, Ninth street, San Bernardino.		Heap wells, Ninth street, San Bernardino.		Katz-Walkinshaw wells.	
Date.	Discharge.	Date.	Discharge.	Date.	Discharge.	Date.	Discharge.
1904.		1904.		1904.		1904.	
Feb. 8	121.6	July 5	33.0	Feb. 18	102.0	May 5	99.0
Aug. 26	71.0	Oct. 8	33.0	May 5	90.0	Aug. 4	76.0
Sept. 16	70.5	Dec. 29	33.0	Aug. 3	71.5	Oct. 11	76.1
Oct. 7	66.9			Sept. 16	71.5		
Dec. 29	65.0			Oct. 8	71.5		
				Dec. 29	71.5		
1905.		1905.		1905.		1905.	
June 2	107.2	June 10	41.9	June 10	71.6	Jan. 5	68.1
July 6	102.0	July 17	45.1	July 17	86.5	May 26	88.5
Oct. 5	87.4	Oct. 5	39.0	Oct. 5	61.0	July 17	72.6
						Aug. 4	66.6
						Sept. 28	61.8
1906.		1906.		1906.		1906.	
July 19	176.6	Jan. 1	23.0	Aug. 1	102.0	Aug. 15	85.7
Aug. 23	168.8	Aug. 1	54.4	Aug. 23	85.8	Aug. 23	92.8
Nov. 8	158.7	Aug. 22	57.8	Nov. 8	81.5	Nov. 8	60.9
		Oct. 23	54.2				
1907.		1907.		1907.		1907.	
Year none.		Not measured.		Aug. 29	177.7	Not measured.	
				Sept. 28 capped.			
1908.		1908.		1908.		1908.	
Apr. 21	278.1	Not measured.		Mar. 21	147.3	Not measured.	
July 28	195.1						
Aug. 13	195.1						
Sept. 5	174.4						
1909.		1909.		1909.		1909.	
Sept. 28	209.9	Not measured.		Sept. 28	89.1	Not measured.	
1910.		1910.		1910.		1910.	
May 26	195.8	Sept. 22	81.0	Sept. 22	98.2	Dec. 22	105.0
June 11	192.8			Nov. 8	72.8		
July 9	179.2						
Aug. 9	216.2						
Aug. 27	204.6						
Sept. 28	209.8						
Nov. 8	245.4						
1911.		1911.		1911.		1911.	
June 16	277.0	June 16	90.0	June 16	129.5	June 27	117.0
July 25	241.6	July 25	80.0	July 25	114.7	July 21	107.8
Aug. 17	240.4	Aug. 29	80.0	Aug. 29	107.2	Aug. 3	99.0
Sept. 21	242.8	Sept. 20	80.0	Sept. 20	107.2	Aug. 21	99.0
				Oct. 18	147.4	Sept. 20	94.6
1912.		1912.		1912.		1912.	
June 24	256.8	June 22	115.0	June 22	124.3	June 24	112.4
July 18	226.4	July 16	104.0	July 16	119.1	July 16	112.4
Aug. 27	227.8	Aug. 24	96.6	Aug. 24	105.8	Sept. 19	90.4
Sept. 25	212.5	Sept. 19	98.6	Sept. 19	104.3		

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A suggestion as to the most important cause of these marked fluctuations of ground water surface is to be found in their similarity to the broad rainfall fluctuations, as shown by the residual mass curve for San Bernardino (Fig. 3). This curve as previously explained should exhibit the same tendencies as natural ground water fluctuations in the region for which it is prepared. A comparison of the data of Tables 17 and 18 and Fig. 3 show a marked similarity in general tendencies. The broad fluctuations of ground water surface during the last twelve years are, therefore, consistent with rainfall and run-off variations during the same period.

Artesian Conditions.

The only available series of measurements of artesian flow covering the period under investigation are those of the Riverside Water Company. These are not complete, nor do they represent in all cases the flow of a well or group of wells as influenced solely by natural conditions. There have been selected from the company's records four sets of measurements which are fairly complete and register natural tendencies most accurately. These are the McCrary tract wells, a group on Warm Creek, near base line 1¼ miles west of Harlem Springs; the Cooley Tract well on Warm Creek, between Ninth and Sixth streets; the Heap well on Ninth street just west of Warm Creek, and the Katz-Walkinshaw wells west of Warm Creek at First and D streets, San Bernardino. The McCrary Tract wells are situated just west of the buried hills, previously described along the line of the Harlem Springs defile, and pressures here should register very quickly any changes in rate of ground water supply. The Cooley and Heap wells are situated 1½ miles further west and their fluctuations might be expected to lag a little. The Katz-Walkinshaw wells are still further west, but hardly far enough to be directly affected by Lytle Creek, and hence would have greater lag than the Cooley and Heap wells. The records confirm these probabilities (Table 20 and Fig. 10). The McCrary well records show that artesian flow decreased steadily from year to year from 1898 to 1904, inclusive, with slight recoveries in the spring of 1901 and 1903. Beginning with 1905 there was a marked recovery culminating in 1907 or 1908. Following this was a period of comparative stability with a slight gain in 1911, and falling off in 1912. The same general fluctuations are shown by the other artesian well records, but with less intensity. Following the year 1904 there was a lag of one year in the Heap and Cooley well, and two years in the Katz-Walkinshaw wells before the effect of increased rainfall of 1905 and 1906 was felt.

These fluctuations correspond in their general tendencies with the fluctuations observed for free ground water surface throughout the basin (Tables 17 and 18). This is to be expected, since artesian flow is controlled by artesian pressure and artesian pressure controlled by the level of free ground water surface surrounding the artesian basin. Hence water spreading has had no more to do with increased artesian

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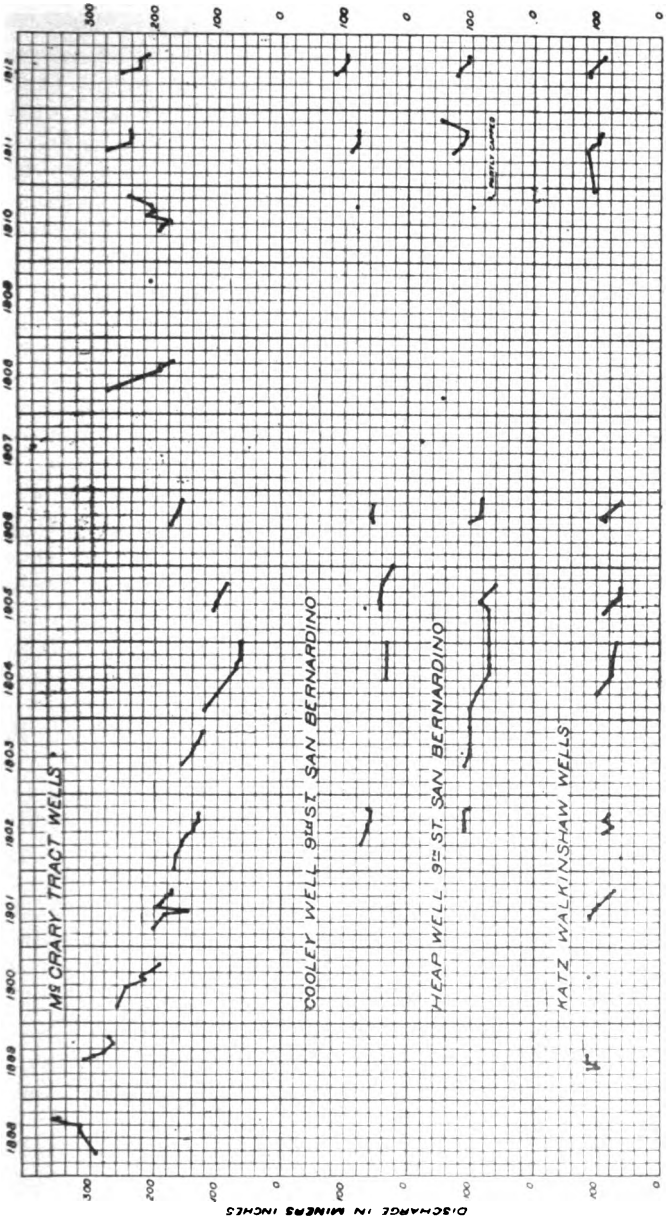
McCRARY TRACT WELLS
COOLEY WELL, 9TH ST. SAN BERNARDINO
HEAP WELL, 9TH ST. SAN BERNARDINO
KATZ WALKINSHAW WELLS
DISCHARGE IN MINERS INCHES

FIGURE-10-DISCHARGE OF TYPICAL ARTESIAN WELLS IN SAN BERNARDINO VALLEY

flows in these wells since 1904 than with the recovery of free ground water levels. Since observations on ground water levels showed consistent and similar fluctuation throughout the basin, there is every reason to believe that artesian flow throughout the basin would follow the same variation as has been observed in these four groups of wells. The McCrary wells are so located that they could not be directly

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benefited by the water spreading as carried on, yet they exhibited marked recovery even before water spreading was attempted on the upper Santa Ana fan. There is no possible conclusion but that ground water recovery has been in large part the result of some other cause than water spreading.

The systematic and thorough capping of flowing wells throughout the basin which has been accomplished during the last few years may be partially responsible for the remarkable recovery. Prior to the dry years the importance of conserving artesian water was not realized and many of the large wells were allowed to flow summer and winter, whether needed or not. By the year 1904 most of the big irrigation company wells were equipped with caps which were closed down during the winter. Through local agitation in southern California a law was passed by the California State Legislature in 1907 and amended in 1909, declaring artesian wells a public nuisance when not equipped with proper mechanical devices with which to arrest their flow, and the waste of artesian water was declared misdemeanor. The efficient administration of this law was brought about in the San Bernardino Valley through the appointment of an officer by the district attorney of San Bernardino County, whose duty is to inspect all flowing wells and keep the district attorney informed regarding cases of failure to obey the law. As a result of these efforts practically all private, as well as company, wells have been closed since 1909, and unnecessary losses from the basin reduced to a minimum. This work has assisted in conserving the natural increase in the rate of recharge of the basin, and is of great public benefit.

However, the most important cause of ground water recovery is to be found in the increase of natural ground water supply as exhibited by precipitation. A careful comparison of the flow of the McCrary wells and the residual mass curve of precipitation at San Bernardino shows a remarkable agreement even to the details (Figs. 3 and 10). The observed flow of 1898 has never been exceeded since nor has the aggregate returned to the high level of 1898. Both have returned to conditions of 1899, however. The decrease in flow continued from 1898 to 1904, inclusive, with slight spring recoveries in 1901 and 1903, just as exhibited by the mass curve. Marked recovery commenced in 1905 and continued to 1907, following which was a period of little fluctuation to date, with the slight increase in 1911, and falling off in 1912. A more perfect agreement of related variables could hardly be expected. The dependence of ground water fluctuations upon precipitation is thus established beyond a doubt.

The investigation of artesian boundaries and swamp conditions still further corroborate these conclusions. The limit of the area underlaid by artesian pressure as indicated by existing wells has been determined several times in past years, and was again determined for the purpose of these investigations. The approximate original artesian limit, the limit in 1900 and again in 1904, has been indicated by Mendenhall

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(Plate I).[1] The original limit represented conditions as they were at their maximum in the late eighties. The limit of 1900 was very much smaller, the area having been reduced by about 50 per cent. The limit of 1904 was still further shrunken. From all information at hand the limit of 1904 was the minimum reached as a result of the years of drought. Since 1904 there has been a gradual expansion of the area. In the spring of 1912, following the storms of March and early April and preceding the opening of large flowing wells in May, the boundary was found to have advanced on all sides of the basin, from what it was in 1904, by distances of from one fourth to one and one fourth miles (Plate I). Although the advance was greatest along the east border of the basin where the slope is flat, yet the recovery is equally great on the north where the slope is steeper. Many wells of moderate depth near and in San Bernardino which originally flowed, but had not done so for twelve or fifteen years, commenced to flow again about the year 1909 and have continued to do so since with increasing pressure. Hence, the limits of artesian flow have exhibited the same general tendencies as have precipitation, ground water levels and artesian flow from deep wells.

In connction with the study of artesian limits a very interesting fact has been noted. Although this remarkable expansion of the artesian area was noted in late April of 1912, yet in May, when the large artesian wells operated by the Riverside Water Company and the Gage Canal were opened, the artesian pressures throughout the basin were so reduced that the flow ceased from many of the wells outside of the minimum area of 1904. The opening of the Riverside Water Company's wells was also accompanied by the sudden drop of water level already noted for Well 337, San Bernardino quadrangle (Table 19). The boundary was determined again on October 9, 1912, four days after the closing of many Riverside Water Company wells as a result of the rain storm of October 2d and 3d. The artesian limit on October 1st was practically that determined by Mendenhall in 1904, and represented conditions following the summer irrigation period with all wells still open which had been uncapped during the summer. On October 4th and 5th and thereafter, immediately following the closing of the Riverside Water Company's wells, wells outside the minimum area began to flow or rise rapidly in the casing and by October 9th the artesian limit had advanced well out toward the limit of late April. The storm of October 2d and 3d followed a long dry summer and produced no appreciable run-off from the mountains. It could not, therefore, be ascribed as the cause of the rapid expansion of the artesian limit. The only explanation is that the pressure relief afforded by many large flowing wells ceased and pressure throughout the basin returned to that of the spring except as reduced by the water taken from the basin during the summer. That this condition occurs each year is shown by the common statement of farmers within the zone of expanded

[1] Mendenhall, W. C., Water-Supply Paper No. 142, U. S. Geol. Survey, 1905. Plate VII.

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artesian pressure around the 1904 limit, that their wells flow in the winter and spring time, but cease just as soon as the deep flowing wells are uncapped. The condition is interesting in connection with the Coastal Plain artesian basins where ground water levels have not recovered materially since 1904 and where attempts to close artesian wells during the winter months have not been successful. The basins are not similar as regards the alluvial material and relation of natural ground water supply to artificial draft, but yet the conclusion is justified that the capping of artesian wells when not in use is a very important step toward conservation of ground water resources.

Returning again to the San Bernardino Valley artesian conditions, there is still further evidence regarding the relation of artesian pressure and of accumulated rainfall excess or deficiency. A very important ground water outlet is evaporation from lands kept moist from below by artesian pressure forcing water up through the pores of comparatively impervious overlying clays, or through larger natural openings. Where the soil is kept quite wet there is a swamp condition with rank vegetation. The evaporation from such a surface is greater than that from a free water surface. The extreme fluctuations of artesian pressure are accompanied by corresponding changes in the intensity of such surface conditions. It is a matter of common knowledge that the lands north and east of San Bernardino, which were very swampy about 1890, were completely drained during the drought ending in 1904, and as a result have been put under a very profitable cultivation. The ranch of Mrs. A. Tompkins, between Seventh and Fifth streets, west of Mount Vernon avenue, was thus drained. The lower portion of this ranch was formerly an impassable swamp in which cattle bogged down and from which a stream of seepage water flowed. The swamp disappeared during the dry period and since then has been continuously farmed. About the year 1910, however, the ground water level began to rise beneath this land and swampy conditions reëstablish themselves. In the winter of 1910–11 the stream of seepage water reappeared. If artesian pressures continue to increase this land will eventually return to its former condition. Other lands are experiencing a similar return to swamp conditions.

Judging by such evidence as this the depleted ground water conditions culminating in 1904 were not entirely due to the great increase in ground water development, which marked the immediately preceding years. It is reported by old residents that for a few years prior to the wet winter of 1883–84 lands northwest, north and east of San Bernardino along Base Line to Harlem Springs were quite as dry as in 1904, but that following that and the subsequent wet seasons, the swamp area expanded rapidly to the extreme of the late eighties. The precipitation mass curve for San Diego and San Bernardino (Fig. 3) both indicate that depleted ground water levels existed prior to the season 1883–84, which were fully as low as in 1904. Hence, there is reason to believe that depleted ground water conditions, nearly, if not fully as extreme

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as those of 1904, have occurred in past years and that the basin was fully recharged by natural agencies alone.

It can be said that there is no evidence to be found in a study of available data regarding ground water levels, artesian pressure, or surface conditions in the San Bernardino basin which shows appreciably the effect of water spreading on the Santa Ana fan, or which can not be explained as the result of natural causes. If the record of ground water fluctuations in the immediate vicinity of the spreading-grounds were available, however, there is no doubt but that they would show very appreciably the effect of water spreading by the unusually shallow depth of the local ground water plane. The area of the whole basin is so great and the movement of ground water so slow that the general effect throughout the basin is still inappreciable and will not be recognizable until a series of dry years occurs.

GROUND WATER FLUCTUATIONS IN OTHER BASINS.

The ground water situation in most of the basins of southern California is so complicated by artificial conditions that investigation for the purpose of comparison with the San Bernardino basin would lead to no conclusions of value. Water spreading has been practiced in San Jacinto Valley, in the lower San Gabriel Valley, along the upper border of the Coastal Plain near Orange and on the alluvial fans of San Antonio and San Dimas creeks. There has been very little attempt to cap flowing wells when not in use in the Coastal Plain artesian area. Furthermore, in most of the southern California ground water basins, except San Bernardino, the artificial draft bears an excessive ratio to the rate of recharge. The San Fernando Valley is the only one which during the last fifteen years has not experienced any of these artificial interferences with natural ground water conditions.

This valley is a typical ground water basin fed largely by percolation from streams draining the San Gabriel Mountains. The formation of the material filling the valley is not favorable for artesian flow but the development of ground water within the valley by pumping is entirely practical. The movement of percolating waters is through the porous gravels toward the lowest depression of the valley where the ground water plane is close to the surface. The natural outlet is by evaporation from the cienaga thus formed, and by the escape of ground water through springs and seepage into the channel of Los Angeles River, which flows out of the valley by way of the "Narrows" south of Burbank. This stream is the overflow from a great storage reservoir and as is to be expected is very uniform in flow. The city of Los Angeles depends upon the flow of the river for its municipal supply in conjunction with pumping plants and infiltration galleries along the channel. The city has kept a record of the discharge of the stream exclusive of flood flow since 1898,[1] which is reproduced as Figure 11.

[1] Mulholland, William. Eleventh Annual Report of the Board of Public Service Commissioners of City of Los Angeles, June 30, 1912.

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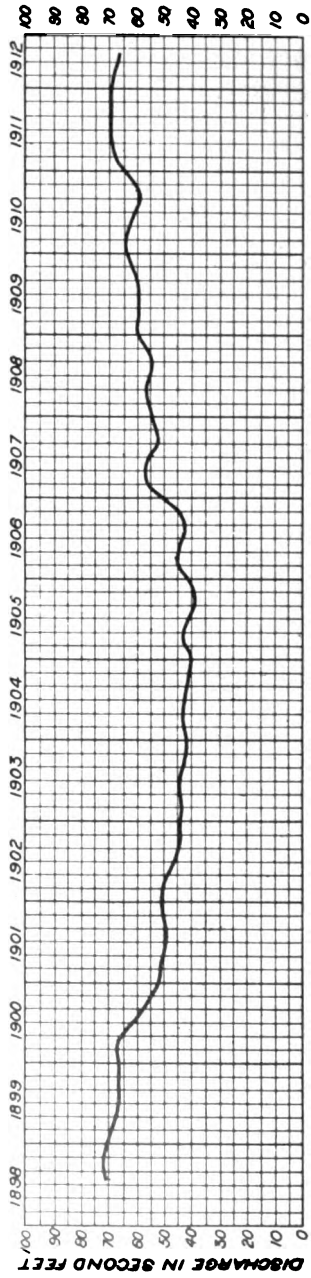

FIGURE 11-DISCHARGE OF LOS ANGELES RIVER EXCLUSIVE OF FLOOD FLOW FROM 1898 TO 1912

There is a striking agreement in the broad fluctuation in flow of Los Angeles River, the fluctuation of ground water level and artesian flow in San Bernardino Valley, and the residual mass curves of precipita-

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tion at San Diego and San Bernardino (Fig. 3). The similar curve for Los Angeles, although not presented in this paper, agrees closely with that at San Bernardino as inspection of Fig. 2 will show. A careful comparison of the detail of the mass curves and flow of Los Angeles River show a close similarity, although there is a tendency for the annual precipitation differences to lag one year before appearing in the river flow. This is to be expected, however, because of the slow movement of ground waters from the upper alluvial slopes to the region of outlet. The variation in flow of Los Angeles River, exclusive of flood flow, is controlled solely by ground water fluctuations. It can, therefore, be said that the San Fernando basin, whose ground water fluctuations are the result of natural causes alone, is subject to similar annual rainfall variations with San Bernardino basin and exhibits similar ground water fluctuations. This still further supports the conclusion that water spreading in San Bernardino Valley has filled a minor place in bringing about a recovery in ground water supply.

CONCLUSIONS.

1. The control of surplus flood water of Santa Ana River and Mill Creek by artificially increasing percolation therefrom into the porous gravels of the alluvial slope for the purpose of increasing the ground water supply of San Bernardino Valley is a commercially practical work of great public benefit, provided it is carried on so as to bring about over-year storage regulation.

2. The work as carried on by the Water Conservation Association is accomplishing the storage of approximately 12,000 acre-feet per annum at an annual cost of 15 cents per acre-foot, or 30 cents per acre irrigated therefrom. The immediate loss of flood water from the basin is being reduced from 54 per cent of the surplus flood flow as formerly occurred to 30 per cent.

3. The work of water spreading has not yet been carried on long enough, nor on a large enough scale, to have appreciably affected general ground water conditions by raising the water plane or increasing artesian pressures. The observed recovery in the San Bernardino Valley is primarily the result of a period of several years during which annual precipitation was above normal, following a period of protracted drought.

4. The capping of artesian wells when not in use is an expensive and practical way of conserving ground water supplies, which should be systematically and thoroughly practiced in every ground water basin where the ratio of artificial draft to natural outflow is large.

5. The subterranean storage of surplus flood waters by artificial methods for the purpose of increasing over-year storage, can, and should be, carried on more extensively in the future so as to hold back a greater proportion of the large floods which occur on Santa Ana River and Mill Creek, as well as other streams in the San Bernardino Valley.

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Ground Water Resources of Indian Wells Valley California

The State Conservation Commission in co-operation with the United States Geological Survey, GEORGE OTIS SMITH, Director

Prepared under the direction of W. C. MENDENHALL, Geologist in Charge of Underground Water Investigations

By CHARLES H. LEE

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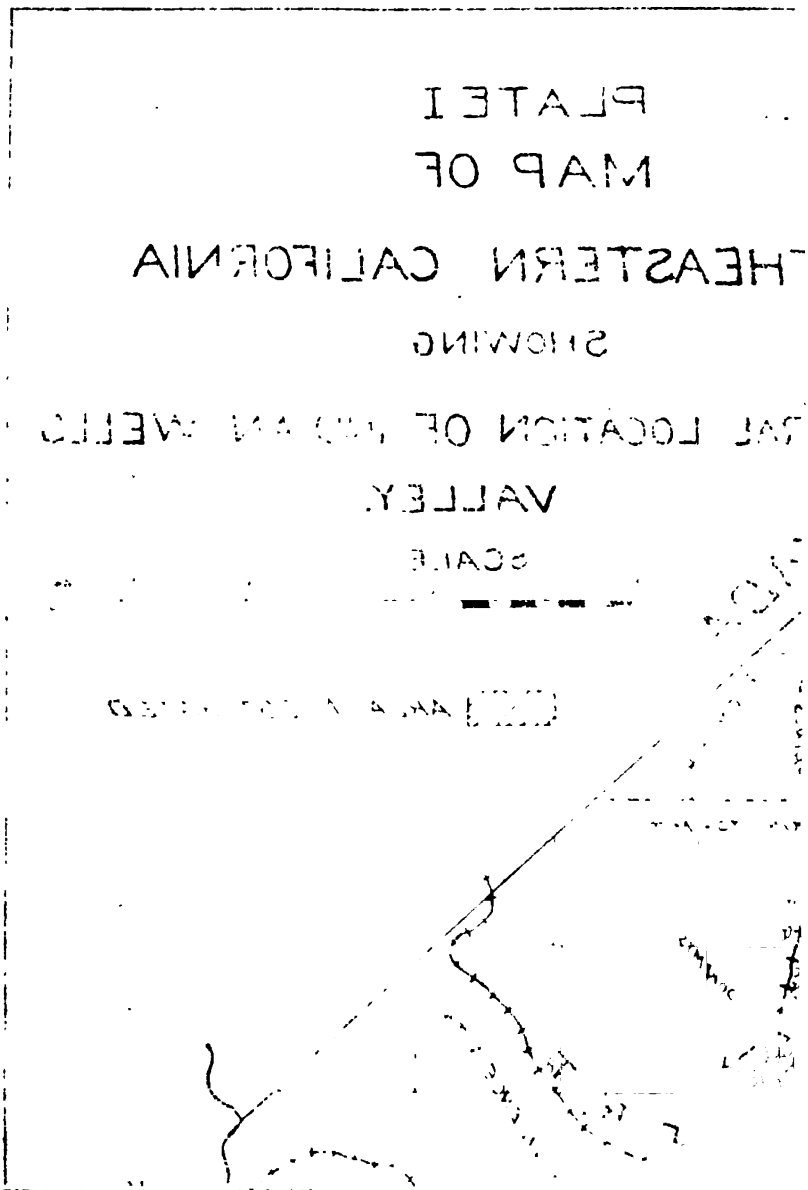

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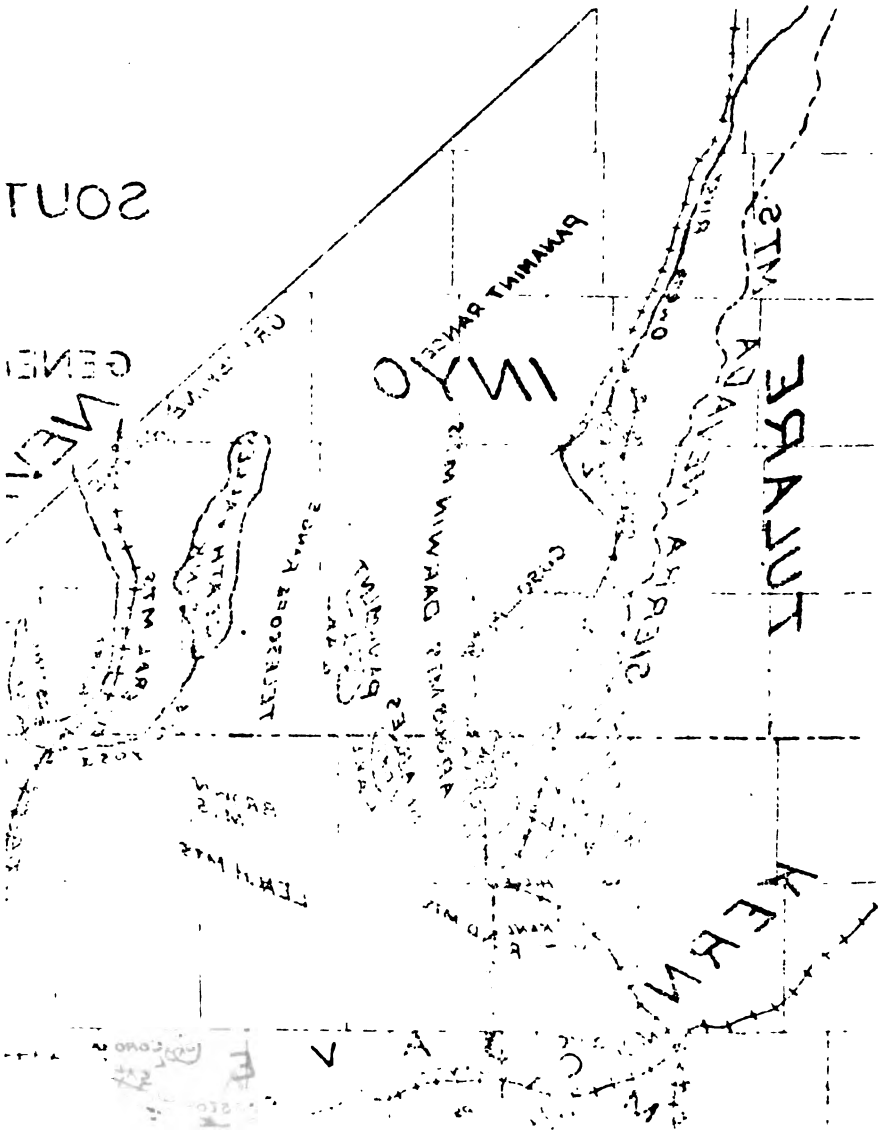

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GROUND WATER RESOURCES OF INDIAN WELLS VALLEY.

By CHARLES H. LEE.

The existing high price of land in the settled portion of California has led many prospective homeseekers and farmers to take up unappropriated government lands under the provisions of the Desert-Land and Homestead Acts. Most of the unoccupied government land which can be cultivated lies in the desert portions of the State, principally in that great area of southeastern California known as the Mojave and Colorado deserts and the Death Valley region. The extreme aridity of this area makes farming impossible without irrigation. There are only three streams, Owens, Mojave, and Amargosa rivers, originating from precipitation on the tributary mountain slopes, which are of sufficient size to flow from their canyons without sinking immediately into the desert sands. These rivers are available as sources of irrigation supply to very limited portions of the whole desert area and agricultural lands most favorably situated for receiving such waters have long ago passed into private possession. The only available source of supply for most of the desert lands upon which entries have been made in recent years is water which may be drawn from the porous gravels underlying such lands. The supply thus obtainable will prove sufficient to irrigate a small portion of the agricultural lands in each valley, but it is far from being enough to irrigate all such lands. The average settler has no conception of how to estimate the volume of ground water which can be pumped without lowering the water level beyond practical pumping limits. The wonderful success with which ground water is being developed in the valleys of southern California has led many people to believe that the desert ground water supplies are equally large. Many families are building homes on the desert, putting down wells, installing pumps, and preparing land for irrigation with the firm belief that their efforts to reclaim the desert will be crowned with success. The purpose of this paper is to describe the ground water conditions in Indian Wells Valley, a typical desert valley which is being rapidly settled, and show how much water can be developed by pumping and how much land irrigated. The ground water conditions of nearly all the desert valleys of southeastern California are exactly similar, although the amount of water which can be pumped differs according to local conditions in each valley. The discussion and data regarding the ground water supply of this valley will be a valuable guide to those interested in other valleys of the desert region.

The investigations were carried on by the Conservation Commission of the State of California. The writer was in charge of the planning and execution of the work. Mr. W. H. Spear gathered the well data

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and made such field surveys as were necessary. The settlers and local well drillers furnished much valuable information and rendered every possible assistance. The field work was performed during September and early October, 1912.

TOPOGRAPHY AND GEOLOGY.

Indian Wells Valley, formerly called Salt Wells, lies mostly in the northeastern corner of Kern County (Plate I). The northern part extends into Inyo County and the eastern border is in San Bernardino County. Townships 25 and 26 south, range 39 east, Mount Diablo meridan, and townships 25 and 26 south, range 40 east, lie wholly within the valley. Considerable portions of townships 25, 26 and 27 south, range 38 east, and township 27 south, range 39 east, are also within its borders.

The old stage route from Mojave to Keeler lies along the western border, as do also the well-known desert springs at Freeman and Indian Wells. The Los Angeles Aqueduct, bringing water from Owens Valley to Los Angeles, has been built through the mountains to the west from Little Lake to Indian Wells. Near the latter point it passes out into the valley and extends southward to Red Rock Summit. The railroad recently constructed by the Southern Pacific Company from Mojave to Owens Valley passes through the Indian Wells Valley and its advent has greatly stimulated settlement. Two small towns have been laid out near the railroad at Inyokern and Brown, and serve as centers for the southern and northern sections of the valley. The area of land within the valley which has been recently filed on at the United States Land Office at Independence, California, is about 130 sections. It comprises the two easterly tiers of sections in townships 25 and 26 south, range 38 east; townships 25 and 26 south, range 39 east; the two westerly tiers of sections in township 25 south, range 40 east; and all except the two easterly tiers of sections in township 26 south, range 40 east. (Plate II.) About one fifth of this area has been cleared of desert brush. Improvements are to be found on about one fourth of the filings and consist of homestead cabins and outbuildings, fencing, drilled wells and, in a few instances, power pumps. There have been drilled, altogether, more than one hundred "stovepipe" casing wells, varying from 100 to 750 feet in depth.

The length of the valley-floor from north to south is about 15 miles and in its greatest width 16 miles. The area of the valley floor, not including the high mesa extending to the southeast is about 213 square miles. Of this area possibly 130 square miles, or 83,000 acres, could be cultivated and crops raised by irrigation if sufficient water were available. The general slope of the central and northern portion is to the east and southeast toward the low depression known as China Dry Lake. The southern part of the valley slopes northeast toward this lakebed. Elevations vary from 3,000 feet above sea level along the base of the Sierra Nevada Mountains, on the west to 2,120 feet in the

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st depression of the dry lake bottom. The slope of the ground is pest near the mountains and decreases toward the lake bottom. The p per mile near Brown is slightly more than 50 feet. A few miles of Brown it is 20 feet per mile and continues thus nearly to the bottom. At Inyokern the drop is about 40 feet per mile and

PLATE III.—Old shore line of China Lake near outlet.

creases to about 30 feet per mile at a point four miles from the lake ttom. Beyond this point to and across the lake bottom the surface is most level. The lake bottom varies from 2,140 feet at the upper end 2,120 at the south.

The most interesting feature of the valley topography is this dry lake

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(Plate II). It occupies the lowest depression of the valley towar which all drainage lines are pointed and is a typical playa lake of th desert, known in different localities as "borax lakes," "salt lakes," o "alkali marshes." (Plate IV A.) It is the evaporating pan fo drainage from the whole valley and its tributary mountains. The lak bottom is a flat expanse of silt and clay. Over the north arm of th lake this is wet and so soft that cattle bog down in it, even in midsummer The southern portion dries out during the summer to a depth of 3 or inches, forming a hard crust beneath which the clay is very moist. I the winter the whole lake bottom is soft and boggy. Surplus floo water collects in it during wet winters but soon evaporates. Whe looking at the lake bottom from a distance, mirage always gives th impression of a great expanse of water, particularly in midsummer In certain portions of the lake bottom and all around the rim an alkal crust is continually forming (Plate III). This sometimes has a thickness of half an inch. The growth of the crystals causes lateral pressure i the crust and as a result it heaves up in ridges and mounds, and eventually cracks and breaks. Walking on it is similar to walking o a thin frozen snow crust except that the moist soil beneath gives better support than soft snow. The crust contains various soluble alkali and saline salts and a small amount of borax. When the alkali is not too strong the moist soils around the rim support a sparse growth of salt grass. The source of the soluble salts forming this crust is to be found in the water which collects in the lake depression from all parts of the valley and precipitates its dissolved mineral content in the process of evaporation. There being no outlet from the basin, these salts accumulate indefinitely.

The valley is completely surrounded by mountains. On the west it is bordered by the Sierra Nevada Mountains, whose crest reaches an elevation of nearly 8,000 feet. The width of the slope tributary to the valley is from three to six miles and is cut by deep canyons. The formation is granite. To the north is an extension of the Coso Mountains and the Argus Range, both of which are parallel with the Sierra Nevada. Between the Coso Mountains and the latter is a narrow defile known as Little Lake Canyon which opens out into Rose Springs Valley. The surface drainage of this region as far north as Haiwee is tributary to Indian Wells Valley. The Rose Springs Valley is really an extension of Owens Valley and in former geologic times the Owens Lake overflowed to the south and found an outlet through the valley and Little Lake Canyon to Indian Wells Valley. The old channel of the river appears at several places near Little Lake and is remarkably well preserved in the lava rock. There are two small basins between the Coso and Argus ranges tributary to Indian Wells Valley. The upper one, known as Coso Basin, contains the Coso Hot Springs, which are residuals of the former volcanic activity of the region. The lower one is really an arm of Indian Wells Valley which has been cut off by a lava flow from the northwest. There is a dry lake bottom in its lowest depression. The Argus Range presents a steep slope toward this

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ower basin and the Indian Wells Valley from the east. It reaches levations between 6,000 and 7,000 feet and is cut with deep canyons. The Coso Mountains are much lower and less steep. Both the ranges how the results of volcanic activity in the form of cinder cones and ava flows. The core of both ranges is granite overlaid with highly netamorphosed slates and schists. The Argus Range shrinks to a low idge of granite hills opposite the center of Indian Wells Valley. The China Lake of former geologic times was fed by the overflow from Owens Lake and found its outlet to Searles Lake through this ridge by way of a narrow gorge cut into the granite. Although partially filled with sand, the gorge is still remarkably well preserved. The level of he outlet is about 40 feet above the present lake bottom. The old hore line of China Lake is as well preserved as the gorge and can be raced along the base of the hills for several miles (Plate III). The Rademacher Hills close the valley on the south. This is a short range of about 20 miles in length, reaching moderate elevations. Between the north end of the range and the Sierra Nevada is a high mesa which at the west falls off rapidly into the Red Rock Canyon.

The total area tributary to China Dry Lake is about 1,050 square miles (Table 1). Of this, 770 square miles is in Indian Wells Valley and the tributary mountain slopes, 200 square miles in Rose Springs Valley, and 80 square miles in the Coso Basin. The area of the mountain slopes tributary to Indian Wells Valley is 360 square miles and the valley floor and mesa 410 square miles.

The present floor of the Indian Wells Valley is formed by the alluvial material which has been carried from the mountain canyons by flowing streams and deposited in the open valley. The depth of this filling varies in different parts of the valley, depending upon the elevation of the impervious floor. The mesa formation at the southwest end of the valley dips to the northeast and is reported by well drillers to lie beneath the modern gravels. In a well 3½ miles northeast of Inyokern it is found at a depth of 300 feet and described as a very tough impenetrable blue clay. In another well six miles northeast of Inyokern the same formation was encountered at 230 feet below the surface. At Terese, 4½ miles southwest of Inyokern on the railroad, a prospect oil well was drilled which encountered this clay or shale at a moderate depth and is reported not to have passed through it at a depth of 1,935 feet. The wells in other parts of the valley do not encounter any underlying impervious formation at depths of from 200 to 300 feet. It is probable that the valley-fill nowhere exceeds 300 feet in depth, and over most of its area does not exceed 250 feet.

The character of this alluvial filling as shown by well logs is typical of similar valleys throughout southern California. There is from 50 to 150 feet of coarse gravel overlaid by finer gravel, sand and top soil. Beneath this gravel is impervious clay from 10 to 50 feet thick. Below this to the impervious floor of the basin are alternating layers of coarse gravel and clay. In the northern portion of the valley considerable water worn lava rock is brought up during drilling operations indicating

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the extent to which Owens River contributed to the work of tran and depositing material. About two miles northeast of Brow still remains a deep channel lined with large lava boulder appears to have been the channel of Owens River before it c flow through Indian Wells Valley. The most active streams we from the Sierra Nevada Mountains as indicated by the great ac tion of alluvial débris along the base of this range.

In conclusion it may be said that the topographic and conditions of the Indian Wells Valley correspond with those recognized ground water basins of California.[1]

PRECIPITATION AND STREAM FLOW.

There are no precipitation records available within the India Valley or the tributary drainage area. The nearest records ap to the region have been made at Mojave, Kernville, Keeler and B (Tables 2 to 5). These indicate a depth of annual precipitati the valley portions of this region of about 4 inches, which chara the climate as one of extreme aridity. The precipitation is gre the Sierra Nevada Mountains, however, as is shown at the highe by the existence of pine trees, which require from 20 to 25 inc annum to make any growth or even sustain life. The winter p tation in the mountains is often in the form of snow.

The relation of elevation and precipitation along the east sl the Sierra Nevada has been made the subject of careful study in years by the engineering staff of the Los Angeles Aqueduc coöperation with the U. S. Geological Survey.[2] The results of studies are presented on Diagram 1. They show that from the s of the mountains eastward to the base there is a uniform decre precipitation with decrease in elevation. After leaving the mou and passing out on to the plains, however, the decrease of pre tion with elevation becomes progressively less. The observed r decrease of precipitation with decrease elevation on the slope Reno, Nevada, called the Central Pacific section, is 1.74 inches pe feet; twelve miles north of Independence, California, in the Ta section, 0.46 inches per 100 feet; the same in Oak section, near pendence; and in Bairs section, ten miles south of Independence, inches per 100 feet. Judging from the local vegetation and precipitation records at Mojave, Barstow and Keeler, the an precipitation at Brown is about 4 inches; at the base of the Si Nevada west of Brown 6 inches; and at the summit 22.5 inches. W this data the dotted line on Diagram 1 has been constructed show the relation of elevation and precipitation in the Brown section. Th is a somewhat similar relation for the west slope of the Argus Ra but the precipitation at the summit probably does not exceed 15 inc per annum.

[1]Mendenhall, W. C.; Water Supply Papers 137, 138, 139, 142, 225, U. S. Geolog Survey.

[2]Lee, Charles H., Ground Water Resources of a Portion of Owens Valley, Californ Water Supply Paper 294, U. S. Geological Survey 1912.

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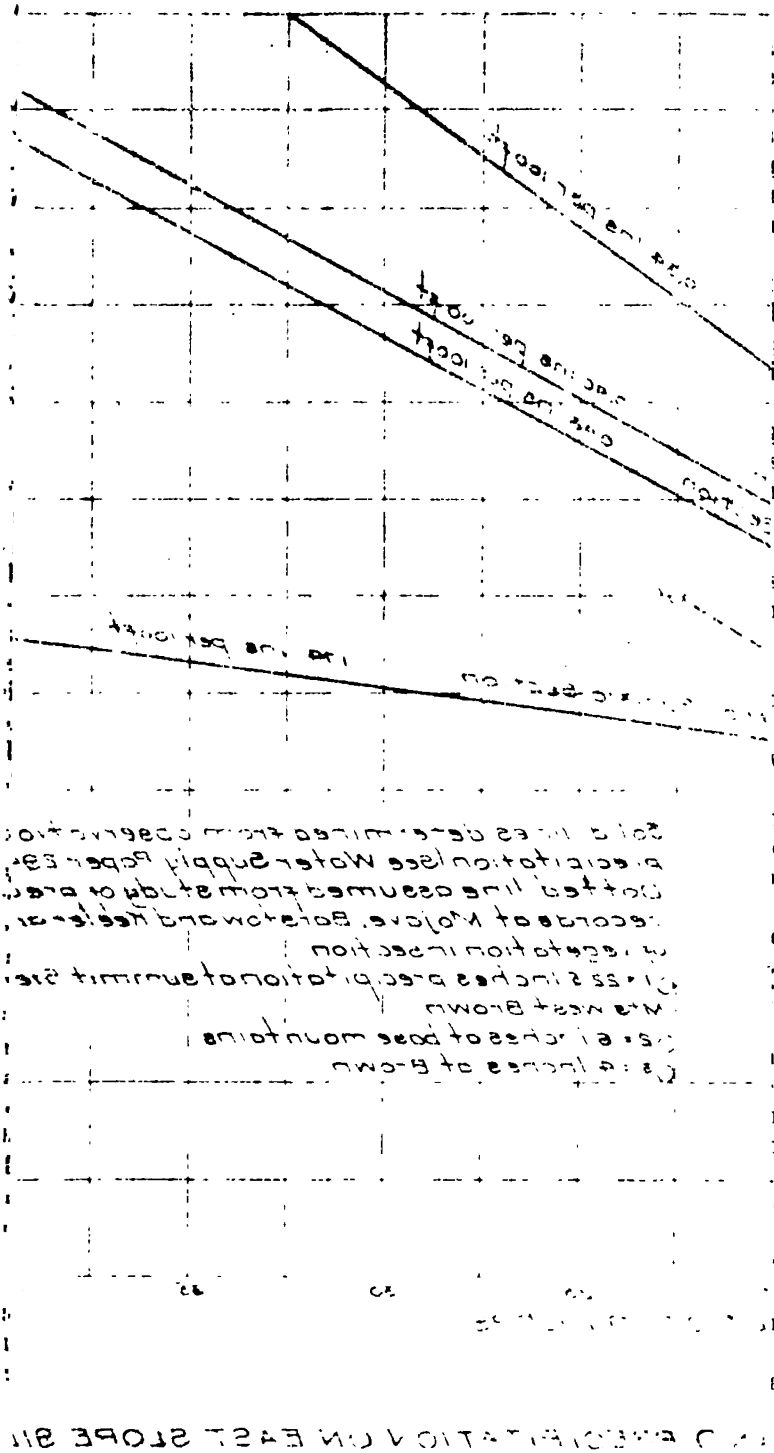

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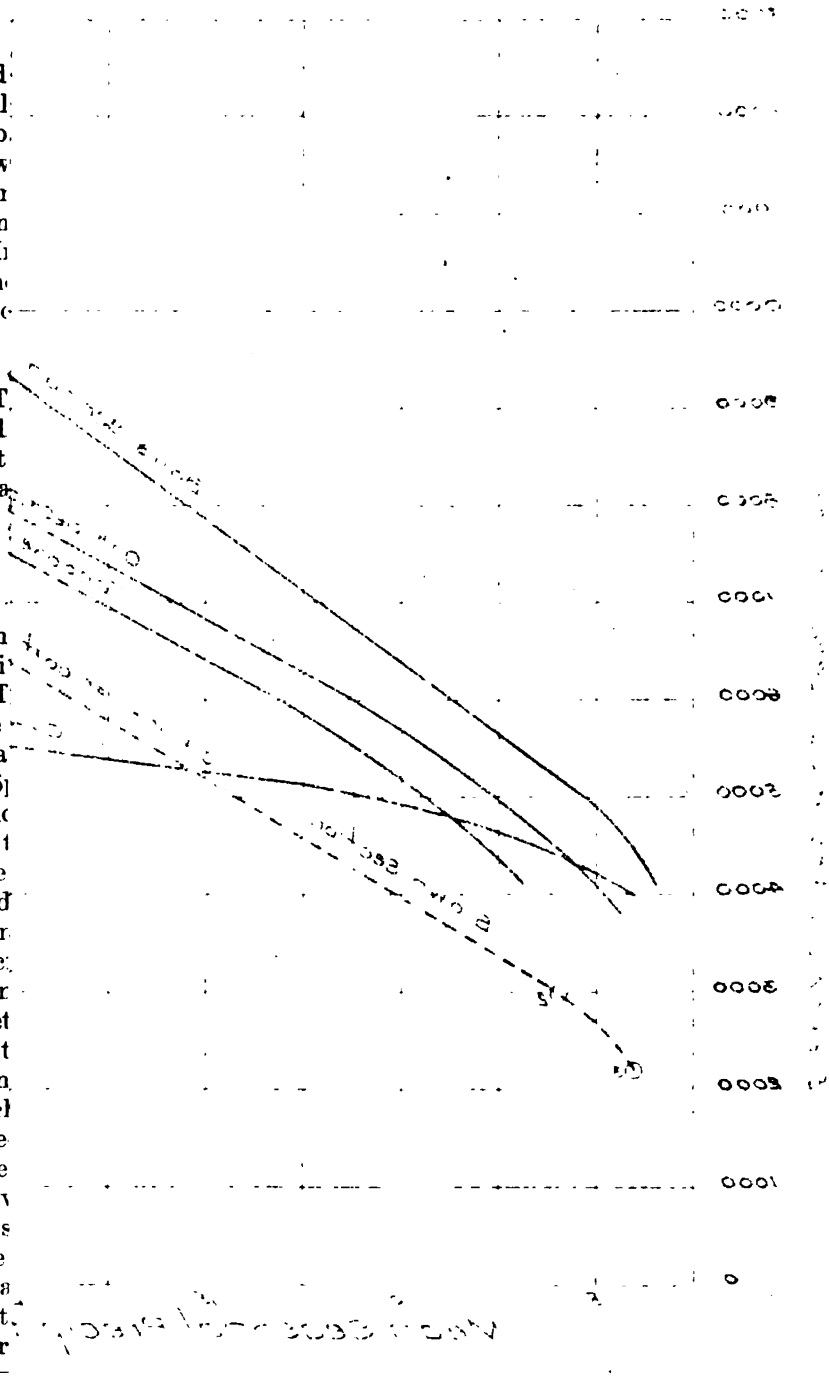

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The monthly variation in precipitation at Mojave is typical of California west of the Sierra Nevada Mountains and in the valley of southern California. There is a rainy season of about five months—November to March, inclusive—followed by a dry period of seven months. Summer storms of unusual severity occur in this region, however, which are peculiarly typical of the desert. They are called cloud-bursts and seldom last more than an hour. A large volume of water falls which, when collected into a narrow canyon, advances in a great wave carrying everything before it. These streams will extend far out into the valleys, depositing their loads of gravel, sand and silt as they advance. These storms are prevalent in July and August; are local in extent and usually gather about the higher peaks of the Sierra Nevada and Argus Range.

The annual variations in precipitation are characterized by great extremes. This is shown strikingly on Diagram 2, which represents the seasonal and three year progressive mean seasonal precipitation at Mojave, Cal. The three year progressive means have been joined by a broken line which shows the annual fluctuations smoothed out so that they are more easily followed by the eye. The mean seasonal precipitation is 5.1 inches, the least recorded during a season a trace, and the greatest 12.7 inches. There have been periods of eight consecutive years when the progressive mean was less than average, and eight progressive years normal or above. The average for three consecutive years has been below two inches per year twice in the last thirty-five years. The effect of such extremes upon the meager water supply of the region is to make it very unreliable.

Run-off from precipitation is almost unknown beyond the mouths of the mountain canyons. The cloud-bursts are the only storms providing sufficient rainfall to form a stream large enough to flow out into the valleys. The ordinary winter storms and slowly melting snows feed small streams in each canyon which, as soon as they reach the open valley, sink beneath the porous sands and gravels and are lost to view. The canyons most productive of run-off are along the slopes of the Sierra Nevada, such as Five Mile, Nine Mile, Sand and Grapevine. The run-off from these four drainage basins, measured at the mouths of canyons, probably would not exceed 100 acre-feet per square mile per year. The canyons of the Argus Range are less productive of run-off than those of the Sierra. The total run-off from the 360 square miles of mountain drainage directly tributary to Indian Wells Valley, measured at mouth of canyons, probably would not exceed 37 second-feet continuous flow, or 27,000 acre-feet per annum.

There is no surface run-off reaching the valley from Rose Springs Valley or Coso Basin. The streams entering these areas are lost into the sands soon after leaving their canyons. Their mountain drainage areas are no more productive than in Indian Wells Valley. It is thus apparent that the surface water supply of the Indian Wells Valley region which is derived from run-off is negligible outside of the

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mountain canyons. The storage of surface water within the canyons for use in irrigation of valley lands is entirely impractical, first, because of the small volume of water available in individual canyons and the excessive cost of constructing storage works; second, because of the excessive evaporation losses from a water surface in this desert region; third, because of the ideal storage reservoir provided by nature in the gravels of the open valley.

THE GROUND WATER RESERVOIR.

The great body of porous gravel lying upon the impervious rock floor of the Indian Wells Valley and surrounded on all sides by rock mountain walls, forms an underground reservoir in which large volumes of water can be stored. The basin in which this gravel has accumulated is impervious and there is no subterranean escape for water when it once enters the gravels. It is held as effectively as if stored in a surface lake or reservoir. The void space in ordinary sand and gravel, as found in nature, is between 20 and 35 per cent of the total volume. Hence in each cubic yard of saturated gravel there is from 40 to 70 gallons of water, or in an acre of saturated gravel one foot deep there is from 65,000 to 114,000 gallons. The depth of the gravels in the valley is possibly 250 feet, and their surface area exceeds 150,000 acres. The large storage capacity of the reservoir is thus apparent.

THE GROUND WATER SUPPLY.

The sources of supply of this reservoir are percolation from the streams which flow from the mountain canyons; percolation from direct precipitation upon the gravel; and underflow from Rose Springs Valley and the Coso Basin. Percolation from direct precipitation is too small to have any appreciable effect in replenishing the ground water supply. The underflow is also very small in amount. The movement of water in the soil seldom exceeds two or three miles per year and ordinarily is much less than this. Most of the underflow from Rose Spring Valley appears in the large spring and meadow at Little Lake and is lost by evaporation. The idea of there being a great stream of underground water from the Owens Valley flowing through Haiwee Meadows, Rose Springs Valley, and on into Indian Wells Valley, is entirely without foundation. The only course that such a stream could take would be through the narrow canyon below Haiwee Meadows where a dam has recently been built by the Los Angeles Aqueduct. This dam rests on bedrock and during the construction of the core well the entire underflow through the canyon, amounting to about 35 miner's inches, was pumped from the trench so that men could work. The source of this water is percolation from the streams originating in small canyons of the Sierra immediately west of the dam and not from Owens Valley. The entire water supply of that valley can be accounted for by evaporation losses from damp meadow and alkali lands and from the surface of Owens Lake. Most of the underflow from the Coso Basin is lost by evaporation from the dry

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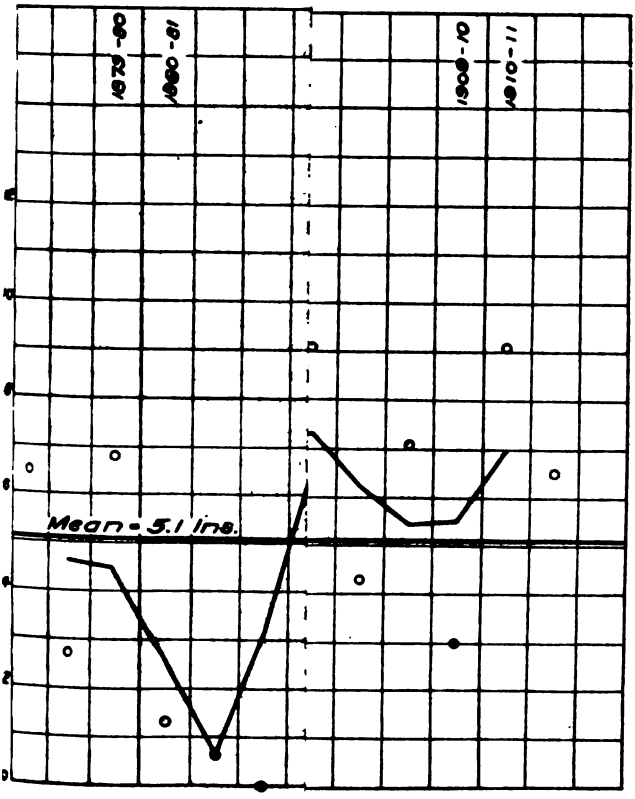

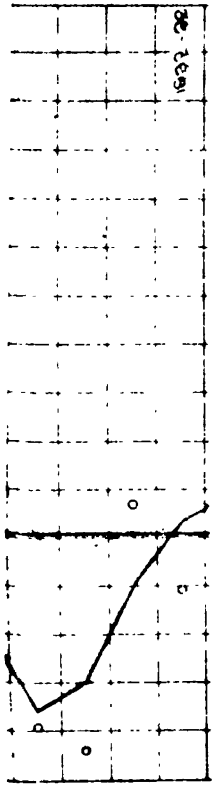

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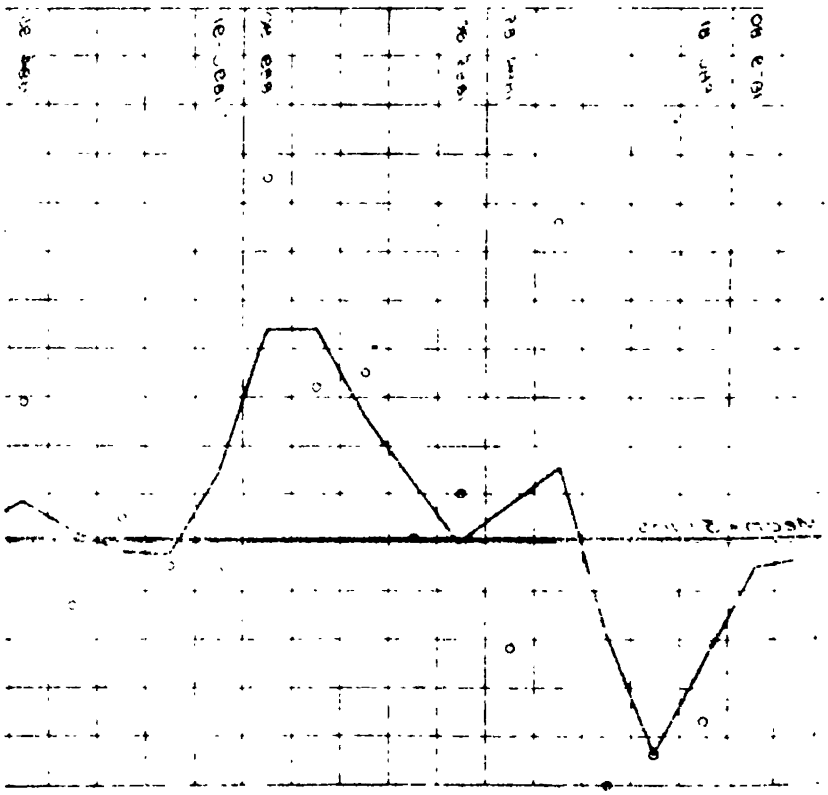

DIAGRAM 2-SEASONAL AND TR
SEASONAL RATES PITA

lake basin in the lowest depression of the second valley. Hence the supply of the ground water reservoir in Indian Wells Valley is derived almost entirely from the tributary mountain canyons, from the little streams which lose themselves in the gravels as soon as they leave the mountains.

As soon as this water enters the porous gravels it percolates downward to the surface of the broad sheet of water underlying the whole valley. This water surface is not level as in a lake, but has a slope towards the east corresponding with the surface of the ground, although not as steep. The slope adjusts itself until the resistance of the gravel to the advance of the water is just balanced by the hydrostatic pressure. The water surface approaches closer and closer to the ground surface in advancing eastward across the valley. Near and within the dry lake-bed the water surface is within eight feet of the ground surface and the water is drawn up by capillary action of the soil and is dissipated into the atmosphere by evaporation. The percolation from the canyon water moves eastward down this slope toward the dry lake and finds an outlet by evaporation from the damp soils around and in the dry lake. The evaporating area is characterized by an alkali crust on the surface of the ground with damp soil beneath (Plate III). The alkali is that which the water had in solution and had left behind when evaporating. It accumulates in the soil from year to year. Although the water itself may be quite pure, the amount of alkali which is deposited during thousands of years is large and as the rainfall is insufficient to carry it away it continues to accumulate.

The average annual inflow and outflow from any reservoir, whether surface or subterranean, must be equal. Otherwise the reservoir would fill to overflowing or dry up entirely. The Indian Wells reservoir cannot overflow until China Lake fills with water to the level of the old outlet to Searles Lake, which is about 40 feet above the lake-bed, nor can it dry up as long as the evaporating area persists. The present conditions and the boundary of the evaporating area have not changed in many years. The inflow and the outflow from the reservoir must, therefore, be equal, considered as annual averages. Measurement of inflow and outflow for the closed ground water reservoir in the vicinity of Independence in Owens Valley has shown them to be equal for that reservoir.[1] Hence the rate of recharge of the gravels of Indian Wells Valley can be obtained by determining the loss by evaporation from the moist lands around within the China Dry Lake. This has been done as described elsewhere in this paper.

The effect of monthly and annual variation in the run-off from the mountain canyons is shown by the rise and fall of ground water levels throughout the basin outside of the evaporating area. Each winter the increased run-off builds up the ground water surface near the mountains and a wave of water starts down the slope. As it advances it flattens out and by the time it has reached the lower valley it is hardly per-

[1] Lee, Charles H., Ground Water Resources of a Portion of Owens Valley, California; Water Supply Paper 294, U. S. Geological Survey. 1912.

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ceptible. It is to be expected, therefore, that wells situated near the mountains will experience an annual rise and fall of considerable amount, the highest level occurring in late winter and the lowest in late fall. Out in the valley in the vicinity of Brown the fluctuation will not be so great and the highest level will be delayed several months, possibly until midsummer. Several miles east of Brown these fluctuations will hardly be noticed at all. The annual fluctuations are of longer duration. A series of wet years will build up the water surface from one year to another until it is considerably above average, while the reverse will occur during dry years. Examination of Diagram 2 shows that periods of eight years drought have occurred in the past when the rainfall was considerably below normal. The effect of such a drought upon ground water levels in the porous gravels of the Indian Wells Valley would be to materially lower them. During the last seven years the average rainfall has been above normal and at the present time the general ground water level is above the normal.

The artificial development of ground water from a reservoir of the type being described is made by sinking wells into the porous material and pumping water from them. The immediate effect is to drain the gravels in the vicinity, particularly on the side toward which the water surface slopes. As long as no more water is pumped than is flowing down the slope within the radius from which the pump draws there will be no permanent lowering of the water plane. If, however, more water is pumped than is supplied the water plane will fall and eventually, if pumping is continued at the same rate, will recede below the level from which the pump draws. The pump might then be lowered, but the only permanent remedy is to reduce the amount of water pumped. Considering the valley as a whole, if more water is pumped from it than is supplied by percolation, the general water plane will fall throughout the valley and the shallow pumps will soon be unable to reach the water plane. When enough pumps have been eliminated to reduce the total amount pumped to the amount supplied by percolation, the water surface will cease falling. If the shallow pumps are lowered and pumping resumed the water plane will again recede. There is no method by which more water can be drawn from a ground water reservoir than is supplied. The effective capacity of a ground water reservoir therefore is not its storage capacity, but is the rate at which the gravels are recharged each year by percolation from the mountain canyons. The amount pumped cannot exceed this if the supply is to remain permanent. It would be impossible to measure the amount of water percolating into the gravels, but it is feasible to measure the evaporation losses. The practical measure of the maximum amount which can be annually pumped from Indian Wells Valley is therefore the annual amount of evaporation from the moist soils in the lowest depression of the valley.

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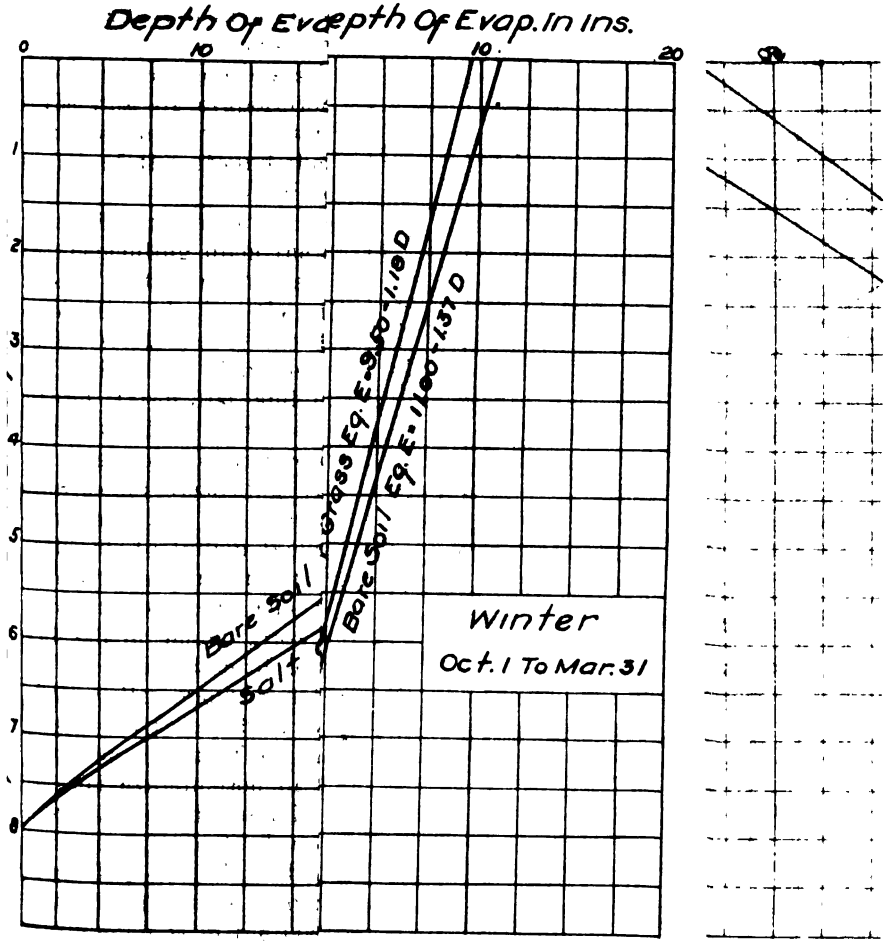

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DIAGRAM 3-INDIAN WELLS VALLEY

EVAPORATION LOSSES.

The subject of evaporation losses from damp soils has never been fully investigated. The most complete set of experiments tending to throw light on the general problem has been recently made in the Owens Valley, California, by the Los Angeles Aqueduct in coöperation with the United States Geological Survey.[1] The conditions under which these experiments were made are almost identical with conditions in Indian Wells Valley, both as to climatic conditions and soil characteristics. The ideas and relations there developed are the basis for determination of soil evaporation losses in Indian Wells Valley.

The rate of evaporation from soil varies proportionally with the depth to the ground water surface. When the ground water is at the surface of the ground there is a definite relation between the rate of soil evaporation and direct evaporation from a free water surface. When the ground water surface reaches a depth of from five to nine feet, depending upon the character of the soil, the evaporation loss is zero. Vegetation such as salt grass will cause a greater rate of soil evaporation during the summer months than from a bare soil. In Indian Wells Valley the depth of annual evaporation from free water surface is about 75 inches, 28 per cent of which occurs between October 1st and March 31st, and 72 per cent during the summer months. The depth at which zero soil evaporation occurs is about 8 feet. From this data and the most recent results obtainable from the Owens Valley experiments regarding the relation of soil evaporation at shallow depths and free water evaporation, were constructed a set of diagrams applicable to Indian Wells Valley (Diagram 3). One set is to be used during the summer months, April 1st to September 30th, and the other during the winter. One pair applies to bare soil and the other to soil with salt or marsh grass growing upon it.

The computation of total evaporation losses from the ground water of the valley requires a knowledge of the areas of bare soil and salt grass lands from which evaporation occurs together with a segregation as to the depth of the ground water surface. This was gained by personal examination of the lower portion of the valley, testing the depth of ground water in various places with a soil auger and making a survey of the outer boundary and subdivision lines of the evaporating area. The data thus obtained is presented in Tables 6 and 7, and on Plate II. The total evaporating area is 14.7 square miles, of which 7.2 square miles is in the lake bottom and the remaining 7.5 square miles borders the lake on various sides. The moist lands east of the lake bed and the adjacent portions of the lake bed are fed by percolating water from the Argus Range, the remaining areas from the Sierra Nevada.

The depth and volume from annual evaporation from each subdivision is presented in Table 8. The ground water surface in such

[1] Lee, Charles H., Ground Water Resources of a Portion of Owens Valley, California; Water Supply Paper 294, U. S. Geological Survey, 1912.

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an evaporating area has a regular annual fluctuation. It is at its highest level about March 15th, gradually recedes during the summer, reaching its lowest level about September 15th, after which it commences to rise. The amount of fluctuation under similar conditions in Owens Valley was about 3 feet between highest and lowest level. The observations of water level were made in Indian Wells between September 15th and 30th, the period of lowest level. Hence the average summer and winter depth to ground water is 1.5 feet less than the observed depth, thus making it possible to fill out the column of average depths in Table 8. The depths of evaporation for summer and winter are taken from Diagram 3. The grand total evaporation loss is 31,630 acre-feet per year or a continuous flow of 44 second feet.

AVAILABLE PUMPING SUPPLY.

It does not follow, however, that this amount of water can be annually pumped from the basin for use on the agricultural lands. About 30 per cent of it is derived from percolation from the Argus Range. The lands between these mountains and the lake are not adapted to agriculture and the cost of developing water east and northeast of the lake and delivering it west of the lake is too great to make it possible from an economic standpoint. There is about 22,000 acre feet of water derived from the Sierra Nevada Mountains and the Rademacher Hills which percolates beneath the agricultural land toward the lake bottom. It is a practical impossibility to intercept all of this subterranean flow because of its diffusion over such a wide area. It is possible that by exercising judgment in locating wells and pumping plants 50 per cent of this volume, or 11,000 acre-feet, could be annually developed for use.

The soils of the valley vary from open sandy loams of the upper slopes to the very fine grained sediment soils of the lower valley which resemble deposits of water-transported volcanic ash. These latter soils are entirely devoid of humus and are almost impenetrable to water. Generally speaking the sandy soils merge into the fine silt between the 2,250 and 2,200 foot contours (Plate II).

The amount of water required to raise crops in the valley will vary from two to eight acre-feet per acre per year, depending upon the crop and the character of the soil. The sandy soil will take almost as much water as is applied to it, while the close soils of the lower valley will not take much more than two to four acre-feet per acre per annum. Fruit trees do not require as much water as field crops. It can be broadly said that the sandy soils will require from five to eight acre-feet per acre per annum and the close soils of the lower valley two to four. The sandy soils will probably require more than this during the first few years of irrigation. It is, therefore, apparent that with the exercise of good engineering judgment in locating wells and farm lands enough water can be developed in Indian Wells Valley to irrigate between 1,500 and 2,500 acres. The area of land which can be con-

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sidered as suitable for agriculture if water were available is about 90,000 acres.

AREA WHICH CAN BE IRRIGATED.

If it is attempted to cultivate permanently 2,000 acres of land in Indian Wells Valley, it should be done in somewhat the following manner: In the first place the unit area of cultivation should not exceed that which can be irrigated from one well continuously or several wells used one at a time. Such an area should not exceed 40 acres. The wells should be so located on each farm unit that they are not closer than 1½ miles to a well on any other farm unit. The best location for these farms as regards water-supply is between the 2,175 and 2,400 foot contours as shown on Plate II. The number of regularly pumped wells in the valley should not exceed fifty and the amount pumped from each well should not exceed 200 acre-feet per acre per year, or 55 miner's inches twelve hours a day for six months.

TABLE 1.

Classification of Drainage Areas Tributary to China Dry Lake, Indian Wells Valley, California.

Basin.	Approximate area in square miles.		
	Mountain slopes.	Mesa and valley floor.	Total.
Indians Wells Valley	360	410	770
Rose Springs Valley	120	80	200
Coso	60	20	80
Totals	540	510	1,050

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TABLE 2.

Precipitation in inches at Mojave, California.

Elevation 2751.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1876-77						.0	0.85	.0	0.01	.0	.0	.0	
1877-78	.0	.0	.0	.0	.0	2.38	1.22	1.74	0.30	0.76	.0	0.02	6.42
1878-79	.0	0.10	0.29	.0	0.32	1.07	0.62	0.05	.0	0.22	.0	.0	2.67
1879-80	0	.0	.0	.0	0.42	4.16	0.40	0.50	0.71	0.60	.0	.0	6.79
1880-81	.0	.0	.0	.0	.0	1.03	.0	.0	0.06	0.18	.0	.0	1.27
1881-82	.0	.0	.0	trace	trace	trace	0.05	0.58	.0	.0	.0	.0	0.63
1882-83	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	trace	.0	trace
1883-84	.0	.0	.0	0.10	.0	0.25	1.77	5.69	2.17	0.61	.0	1.05	11.64
1884-85	.0	0.10	.0	0.13	(0.31)	(1.59)	.0	0.06	.0	0.61	0.14	.0	(2.84)
1885-86	0.71	.0	.0	.0	1.25	1.16	1.49	trace	1.22	0.14	.0	trace	5.97
1886-87	trace	.0	.0	trace	0.76	0.08	trace	4.09	.0	0.14	.0	.0	5.07
1887-88	.0	.0	.0	0.95	0.56	1.06	2.62	1.56	1.75	.0	.0	.0	8.50
1888-89	.0	.0	.0	.0	2.18	2.23	0.35	0.03	3.43	.0	trace	.0	8.22
1889-90	.0	0.81	0.27	2.21	0.45	7.30	0.85	0.58	.0	.0	.0	.0	12.47
1890-91	.0	.0	0.70	.0	0.15	0.67	.0	2.33	0.19	0.36	.0	.0	4.40
1891-92	trace	.0	0.33	0.03	.0	0.76	1.00	0.47	1.61	.0	0.26	.0	4.46
1892-93	.0	.0	.0	.0	0.27	0.56	2.73	0.26	1.53	0.13	.0	.0	5.48
1893-94	1.04	.0	.0	0.29	0.15	0.88	0.48	0.54	0.24	trace	0.03	.0	3.65
1894-95	.0	.0	.0	.0	trace	3.68	2.66	0.53	1.01	.0	.0	.0	7.88
1895-96	.0	.0	.0	0.80	0.14	.0	1.31	.0	1.45	.0	.0	0.22	3.92
1896-97	0.12	.0	.0	0.70	0.17	0.82	1.86	1.17	0.82	.0	.0	.0	5.66
1897-98	.0	.0	.0	.0	.0	.0	0.60	trace	.0	.0	.0	.0	0.60
1898-99	.0	.0	.0	.0	.0	0.29	0.37	.0	0.48	.0	trace	.0	1.14
1899-00	.0	.0	.0	0.68	0.88	0.31	0.31	.0	trace	0.21	0.42	.0	2.81
1900-01	.0	.0	0.01	.0	1.66	.0	0.73	3.18	.0	.0	0.28	.0	5.85
1901-02	.0	1.75	.0	0.52	0.07	.0	0.17	0.86	0.14	trace	.0	.0	3.51
1902-03	.0	.0	.0	trace	0.84	0.21	0.02	0.50	0.35	1.00	.0	.0	2.92
1903-04	.0	.0	trace	.0	.0	.0	.0	0.76	1.20	.0	.0	.0	1.96
1904-05	.0	0.30	.0	.0	.0	0.60	0.70	1.60	2.90	.0	trace	.0	6.10
1905-06	.0	.0	.0	.0	1.25	.0	1.00	1.00	2.00	1.50	trace	.0	6.75

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TABLE 3.

Precipitation in inches at Barstow, California.

Elevation 2105.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1888-89							0.14	0.04	0.93	.0	0.12	.0	
1889-90	.0	0.13	0.07	0.23	0.70	3.87	0.36	0.15	trace	0.07	.0	.0	5.58
1890-91	.0	0.15	0.59	.0	0.05	0.52	.0	2.47	trace	0.05	trace	.0	3.83
1891-92	trace	0.06	0.08	.0	trace	0.25	0.22	0.67					
1892-93							0.11	0.27	0.77	0.06	trace	.0	
1893-94	1.10	.0	.0	0.22	trace	0.72	0.02	0.21	0.06	.0	0.22	trace	2.55
1894-95	trace	.0	.0	.0	.0	0.92	1.06	.0	0.20	.0	.0	.0	2.18
1895-96	.0	.0	.0	0.33	trace	.0	0.16	.0	0.08	.0	.0	.0	0.57
1896-97	0.07	0.87	.0	1.55	0.25	0.30	2.15	0.65	0.11	.0	.0	trace	5.95
1897	.0	0.18											
1903							0.50	0.55	1.00	0.10	.0	trace	
1903-04	.0	trace	0.50	.0	.0	.0	trace	0.30	0.10	.0	.0	.0	0.90
1904-05	0.40	trace	.0	.0	.0	trace	1.10	0.50	3.50	0.40	.0	.0	5.90
1905-06	.0	trace	.0	.0	0.90	trace	0.65	trace	.0	0.25	.0	.0	1.80
1906-07					2.00	trace							
1907-08	.0	.0	trace	3.39	0.02	1.13	1.11	0.76	0.35	0.09	0.18	.0	7.03
1908-09	trace	0.59	0.66	0.42	.0	0.10	1.29	0.94	0.77	.0	trace	0.04	4.81
1909-10	trace	0.50	0.10	0.10	0.31	1.83	1.02	.0	0.30	.0	.0	.0	4.16
1910-11	0.32	.0	.0	0.35	0.03	0.04	0.61	0.77	0.28	0.48	0.02	.0	2.90
1911-12	0.36	.0	1.50	0.08	.0	0.05	.0	.0	1.22	0.21	0.25		3.67
Mean	.14	.16	.23	.44	.27	.65	.58	.46	.57	.10	.05	.0	3.70

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TABLE 4.

Precipitation in inches at Keeler, California.

Elevation 3620.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1884-85							.0	.0	0.12	0.82	.0	0.08	
1885-86	.0	0.11	.0	0.25	0.65	0.36	0.49	0.14	0.60	0.40	.0	.0	3.00
1886-87	0.14	0.08	.0	0.01	0.08	.0	trace	0.93	.0	1.14	0.04	trace	2.42
1887-88	0.52	.0	1.08	0.84	0.01	0.48	0.70	1.21	0.30	0.12	0.30	0.20	5.76
1888-89	0.17	0.10	0.06	.0	1.68	0.82	0.04	trace	0.52	0.12	0.06	0.01	3.58
1889-90	.0	trace	0.08	0.56	0.05	0.56	0.42	0.01	trace	0.10	0.20	.0	1.98
1890-91	.0	1.30	0.40	0.08	0.12	0.16	.0	0.98	0.16	0.10	0.37	0.30	3.92
1891-92	0.06	0.02	0.19	0.04	.0	0.31	0.26	0.19	0.32	.0	0.56	trace	1.95
1892-93	.0	trace	trace	0.81	0.11	0.54	0.71	0.73	0.84	trace	trace	.0	3.74
1893-94	0.41	trace	trace	trace	0.12	0.78	trace	0.29	0.01	trace	trace	trace	1.61
1894-95	0.11	.0	.0	.0	.0	1.05	0.35	1.15	trace	0.25	trace	trace	2.91
1895-96	trace	trace	trace	.0	.0	trace	0.45	.0	trace	trace	0.15	trace	0.60
1896-97	0.25	1.42	0.50	trace	.0	0.25	0.10	0.27	0.13	.0	trace	.0	2.92
1897-98	.0	0.19	0.14	0.15	trace	trace	.0	.0	.0	0.05	.0	.0	0.53
1898-99	.0	.0	trace	.0	trace	0.30	0.40	(0.45)	.0	0.01	trace	0.50	(1.66)
1899-00	trace	trace	.0	trace	1.75	trace	trace	.0	0.16	1.25	0.23	trace	3.39
1900-01	0.10	trace	0.35	0.09	0.45	.0	0.75	0.25	.0	trace	0.40	.0	2.39
1901-02	.0	0.90	.0	0.50	.0	.0	trace	0.25	1.25	.0	.0	.0	2.90
1902-03	trace	trace	trace	.0	0.50	0.10	.0	0.10	trace	trace	trace	trace	0.70
1903-04	.0	.0	.0	.0	.0	.0	trace	0.70	0.50	.0	.0	.0	1.20
1904-05	trace	1.00	0.55	0.75	.0	.0	0.90	1.00	3.30	trace	1.10	.0	8.60
1905-06	.0	.0	.0	.0	1.50	.0	1.05	0.20	(0.20)	0.85	.0	.0	(2.80)
1906-07	(0.11)	.0	(0.18)	.0	0.30	0.10	1.55	0.38	1.12	.0	.0	1.00	(4.69)
1907-08	.0	.0	.0	1.94	.0	.0	0.91	1.08	.0	.0	0.25	.0	4.18
1908-09	0.50	0.58	2.75	.0	.0	.0	0.72	0.30	trace	.0	.0	.0	4.85
24-year mean	.10	.24	.26	.25	.26	.24	.41	.44	.39	.18	.15	.23	3.01

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TABLE 5.

Precipitation in inches at Kernville, California.

Elevation 2600.

Season.	July.	August.	September.	October.	November.	December.	January.	February.	March.	April.	May.	June.	Total.
1893-94							1.10	1.88	0.42	0.17	0.53	.0	
1894-95	.0	0.01	0.60	.0	.0	5.31	5.10	1.55	1.80	0.37	.0	.0	14.74
1895-96	.0	.0	.0	0.50	0.95	0.40	3.52	.0	1.54	0.86	.0	0.20	7.97
1896-97	2.25	0.05	.0	1.48	0.41	0.85	3.40	3.60	2.57	0.10	.0	.0	14.71
1897-98	.0	.0	.0	0.45	.0	1.14	0.47	0.85	0.35	.0	0.40	.0	3.66
1898-99	.0	.0	0.05	0.05	0.17	0.42	2.10	0.40	2.10	0.37	0.41	0.16	6.23
1899-00	.0	.0	.0	0.90	0.89	0.84	0.80	0.53	0.58	0.52	0.90	.0	5.96
1900-01	.0	.0	0.79	0.10	5.09	.0	1.35	2.92	0.15	0.31	1.62	.0	12.33
1901-02	.0	0.70	.0	0.72	0.15	.0	0.30	6.36	2.10	0.74	0.10	.0	11.17
1902-03	.0	.0	.0	0.16	0.85	0.45	2.05	1.75	1.50	0.80	.0	.0	11.24
1903-04	.0	.0	0.10	.0	1.60	0.29	0.20	2.48	2.60	0.43	.0	.0	7.70
1904-05	.0	0.27	0.79	.0	.0	0.72	1.00	3.15	3.90	0.52	1.21	.0	7.88
1905-06	.0	.0	0.10	.0	1.60	0.29	4.02	1.28	6.01	0.69	1.87	.0	13.87
1906-07	0.50	.0	.0	.0	0.50	2.36	2.72	0.76	2.14	0.18	.0	0.11	9.27
1907-08	.0	.0	.0	1.98	.0	1.73	1.34	2.60	0.20	0.19	0.08	.0	8.12
1908-09	0.15	0.10	0.82	0.16	0.92	0.30	8.41	8.52	1.84	.0	.0	.0	21.22
1910-11	0.25	.0	0.15	0.77	0.18	0.74	3.80	0.69	1.73	0.45	.0	0.20	8.96
16-year mean	.20	.07	.21	.45	.83	.99	2.54	2.34	1.94	.41	.41	.04	10.31

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TABLE 6.

Description of Auger Test Holes Within and Near China Dry Lake, Indian Wells Valley.

Test hole.	Location.	Surface characteristics.	Character of material.	Depth to groundwater September 24-26, 1912, feet.
A	NE. ¼ Sec. 25, T. 25 S., R. 39 E.	Light colored smooth clay surface with scattered salt-grass.	2½ feet brownish yellow clay, 1½ feet fine reddish sand cemented, 2 feet fine gray sand with clay, clean quartz sand with water.	6.2 (Moist 4 inches below surface.)
B	NE. ¼ Sec. 25, T. 25 S., R. 39 E.	Thin alkali crust not puffed up. Scattered salt-grass.	4 feet light chocolate clay, 1¾ feet reddish silt to fine sand, 9 inches greenish gray clay, clean quartz sand with water.	6.7 (Moist 3 inches below surface.)
C	SE. ¼ Sec. 31, T. 25 S., R. 40 E.	Hard alkali crust ¼ inch thick and puffed up. No vegetation.	3 feet fine sand, 1 foot transition to coarse sand, 2 feet coarse sand underlaid by crumbly clay.	6.0 (Moist under alkali crust.)
D	Near N. ¼ corner Sec. 4, T. 26 S., R. 40 E.	Thin film white alkali and scattered salt-grass; surface smooth.	2 feet fine sand, 1 foot coarse sand, 1 foot yellowish gray clay, coarse water bearing sand.	4.75 (Surface moist.)
E	SW. ¼ Sec. 36, T. 25 S., R. 40 E.	Tough alkali crust ½ inch thick. Short salt-grass. Surface smooth.	2 feet yellow clay, 9 inches fine green sand, 9 inches tough green clay, 9 inches coarse green sand, 3 inches tough green clay, coarse water bearing sand.	4.3 (Moist ½ inch below surface.)
F	SW. ¼ Sec. 6, T. 25 S., R. 41 E.	Alkali crust puffed up, broken and very uneven surface; scattered salt-grass.	4 feet fine yellow sand merging into coarser sand, clean quartz sand with water.	4.6 (Moist under alkali crust.)
G	Near N. ¼ corner Sec. 13, T. 25 S., R. 40 E.	Thin film white alkali; surface smooth.	Chocolate colored silt	3.2 (Surface moist.)
H	Sec. 9, T. 24 S., R. 40 E.	Thin film white alkali; surface smooth.	Chocolate colored silt with salt crystals	4.13 (Surface moist.)
I	Sec. 9, T. 24 S., R. 40 E.	Thin film white alkali; surface smooth.	Chocolate colored silt with salt crystals	3.23 (Surface moist.)
J	Sec. 9, T. 24 S., R. 40 E.	Thin film white alkali; surface smooth.	Chocolate colored silt with salt crystals	3.00 (Surface moist.)

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TABLE 7.

Classification of Moist Lands Situated Within and Around China Dry Lake, Indian Wells Valley.

No.	Location.	Description.	Area in square mile.	Approximate depth to water in feet September 30.		
				Maximum.	Minimum.	Average.
I.	Upper Lake bottom.	Bare clay mud with slight alkali film; surface wet.	1.86	4	3	3.5
II.	Lower Lake bottom.	Bare hard clay with areas roughened by surface swelling; moist ⅛ of an inch below surface; no surface alkali showing.	5.40	5	4	4.5
III.	Bordering Lake east near old borax works.	Sparse growth salt-grass; alkali crust much broken and puffed up by swelling; moist beneath crust.	1.43	5	3.5	4.5
IV.	Bordering Lake south.	Bare soil; gray alkali crust with white spots; hard, brittle and puffed up; moist beneath crust.	0.64	5	4	4.5
V.	Bordering Lake in narrow zone, various portions.	Sparse growth salt-grass; alkali crust; transition zone from moist lake bottom to desert sands surface moist to dry.	2.00	7	4	5.5
VI.	Bordering Lake in long arm to west.	Sparse growth salt-grass; alkali crust; follows a swale and alkali and salt-grass more prevalent near drainage line.	3.38	6	5	5.5

TABLE 8.

Annual Evaporation from Moist Lands Situated Within and Around China Dry Lake, Indian Wells Valley.

No. of area.	Area in square miles.	Average depth to ground-water, feet.	Depth of evaporation per annum in inches.			Volume in acre-feet.	Equivalent flow, second-feet.
			Summer.	Winter.	Total.		
I	1.86	2.00	40.5	8.30	48.80	4,840	6.7
II	5.40	3.00	33.75	7.00	40.75	11,720	16.2
III	1.43	3.00	38.70	6.00	44.70	3,410	4.7
IV	0.64	3.00	33.75	7.00	40.75	1,390	1.9
V	2.00	4.00	31.00	4.80	35.80	3,820	5.3
VI	3.38	4.00	31.00	4.80	35.80	6,450	8.9
Totals	14.71					31,630	43.7

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WELL DATA.

The well data collected during these investigations is by no means complete. It was planned to visit typical wells in various parts of the valley and determine approximate location, kind of well, depth, use, method of lift, depth to water, approximate elevation of ground surface and, if possible, the log. There were examined in all thirty-nine wells, consisting of about one third the total of wells in the valley. The wells chosen for study are distributed so as to give a knowledge of the depth to water throughout the valley and will be valuable as definite points at which to make future measurements. These wells are listed in Table 9, and their location is indicated on Plate II. The location of the wells is approximate, having been determined in the field by reference to roads, fences or clearings, and in some cases from the owner or driller. The approximate elevation of the surface at each well was obtained by interpolating between contours on Plate II. Depth to water is not from top of casing, but from surface of ground.

The depth to water as measured in the different wells varies from less than 10 feet to 280 feet below the ground surface. The latter depth was observed in well 32, which is located one mile northwest of Inyokern, and is higher up the slope than any of the others. The shallow depths occur near the dry lake basin. The relative positions of the ground surface and ground water surface between the Southern Pacific Railroad and the dry lake bed is shown graphically by the three profiles of Plate V. One profile extends east from the railroad near Brown along the section line one mile south of the Kern-Inyo County line. The depth to water at the railroad is approximately 180 feet and the slope of the water surface 15 feet per mile. This slope gradually flattens out toward the east and since the overlying ground surface is steeper the two surfaces approach each other. Near the west edge of the lake bottom the depth to water is less than eight feet and from here east the water surface is level across the lake bottom. The difference of elevation of water surface between the railroad and the west edge of the evaporating area, a distance of 12 miles, is about 125 feet. The average slope of the water surface is 10 feet per mile.

The next profile is five miles south of county line, about one mile north of Muerto Siding, and extends east. The depth to water at the railroad is about 80 feet and continually decreases until the evaporating area is reached. This profile follows the center of a broad depression extending west from the lake bottom and the ground water conditions correspond with those of the first profile from the 2,300 contour east. The difference of elevation of the water surface between the railroad and the west edge of the evaporating area, a distance of 11 miles, is about 100 feet. The average slope of the water surface is thus nine feet per mile.

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TABLE 9.

List of Typical Wells in Indian Wells Valley.

No. of well.	Owner.	Location.	Class of well.	Approximate elevation of surface. feet.	Approximate elevation of water. feet.	Depth to water. feet.	Depth of well. feet.	Method of lift.	Use of water.
1	S. R. Smith	SE. ¼ Sec. 12, T. 25 S., R 38 E.	Bored 24 inches	2,380	2,248	132.0	337	Gas	Irrigation.
2	S. R. Smith	NW. ¼ Sec. 18, T. 25 S., R. 39 E.	Bored 24 inches	2,340	2,243	97.0	312	Gas	Irrigation.
3	S. R. Smith	NW. ¼ Sec. 19, T. 25 S., R. 39 E.	Bored 24 inches	2,298	2,223	75.0		None	None.
4	H. F. W Shuette	NE. ¼ Sec. 8, T. 25 S., R. 39 E.	Dug 5x6 feet	2,320	2,247	73.0	75	Hand	Domestic.
5	W. J. Eastman	S. ½ NE. ¼ Sec. 9, T. 25 S., R. 39 E.	Bored 7 inches	2,250	2,189	61.1		Hand	Domestic.
6	——— ———	NW. ¼ Sec. 2, T. 25 S., R 39 E.	Bored 12 inches	2,240	2,202	37.5		None	None.
7	M. J. Boynton	S. ½ Sec. 1, T. 25 S., R. 39 E.	Bored 7 inches	2,220	2,198	22.5		Hand	Domestic.
8	——— ———	NW. ¼ Sec. 7, T. 25 S., R. 40 E.	Bored 3 inches	2,195	2,171	24.0		Hand	Domestic.
9	C. C. Paxton	N. ½ Sec. 35, T. 25 S., R. 40 E.	Bored 6 inches	2,140	2,130	9.5		Gas	Stock.
10	Mrs. V. Lovenguth	NE. ¼ Sec. 30, T. 25 S., R. 39 E.	Dug 4½x3½ feet	2,249	2,218	31.2	40	Hand	Domestic.
11	R. B. Clapp	SW. ¼ Sec. 29, T. 25 S., R. 39 E.	Bored 12 inches	2,242	2,212	30.0	206	None	None.
12	Mrs. J. E. Edwards	S.W. ¼ Sec. 20, T. 25 S., R. 39 E.	Dug 5x5 feet	2,245	2,207	37.6	50	Wind	Domestic.
13	V. L. Carr	W ½ Sec. 27, T. 25 S., R. 39 E.	Bored 10 inches	2,210	2,184	25.9	103	Gas	Dom. and irrig.
14	D. N. Shanks	N. ½ Sec. 4, T. 26 S., R. 39 E.	Bored 12 inches	2,250	2,180	70.0		Gas	Irrigation.
15	W. H. Calloway	SE. ¼ Sec. 34, T. 25 S., R. 39 E.	Bored	2,225	2,175	50.0		Wind	Domestic.
16	J. W. Calloway	NE. ¼ Sec. 35, T. 25 S., R. 39 E.	Dug 4x4 feet	2,212	2,177	34.4		Wind	Dom. and stock.
17	E. B. Morse	S. ½ Sec. 10, T. 26 S., R. 39 E.	Dug 12 feet	2,298	2,172	126.0	300	Gas	Domestic.
18	C. B. Walker	NE. ¼ Sec. 31, T. 25 S., R. 39 E.	Dug 3 feet diam.	2,248	2,191	57.1		Hand	Domestic.
19	C. C. Paxton	S. ½ Sec. 31, T. 25 S., R. 39 E.	Bored 7 inches	2,280	2,208	72.0		Gas	Domestic.
20	E. C. Siebenthal	SW. ¼ Sec. 6, T. 26 S., R. 39 E.	Bored 6 inches	2,320	2,213	107.0	110	Wind	Dom. and stock.
21	——— Wachob	SE. ¼ Sec. 12, T. 25 S., R. 39 E.	Bored	2,205	2,189	16.0		Gas	Irrigation.
22	A. L. Pitzer	N. ½ Sec. 13, T. 25 S., R. 39 E.	Bored 12 inches	2,210	2,190	20.0		None	None.
23	E. S. Pitzer	N. ½ Sec. 24, T. 25 S., R. 39 E.	Bored 12 inches	2,195	2,173	21.7	260	None	None.
24	W. M Randall	W. ½ Sec. 14, T. 25 S., R. 39 E.	Bored	2,220	2,187	33.4	200	Gas	Irrigation.
25	O. E. Weisel	NE. ¼ Sec. 27, T. 25 S., R. 39 E.	Bored 6 inches	2,208	2,185	23.1	25	Hand	Domestic.
25a	O. E. Weisel	NW. ¼ Sec. 26, T. 25 S., R. 39 E.	Bored 6 inches	2,205	2,185	20.4	33	Hand	Stock.
25b	O. E. Weisel	NW. ¼ Sec. 26, T. 25 S., R. 39 E.	Bored	2,205	2,184	20.5	101	None	None.
26	M. J. Moor	NE. ¼ Sec. 8, T. 26 S., R. 40 E.	Bored	2,160	2,128	32.2	208	Gas	Irrigation.
27	Horace Bellows	SE. ¼ Sec. 28, T. 25 S., R. 39 E.	Bored	2,210	2,179	30.6	196	None	None.

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29	Dr. Johnson	W. ½ Sec. 24, T. 26 S., R. 39 E.	Bored 14 inches	2,296	2,150	148.0	310	None	None.
30	John Joos	N. ½ Sec. 26, T. 26 S., R. 39 E.	Bored 12 inches	2,350	2,163	187.0	398	None	None.
31	Inyokern Co.	NE. ¼ Sec. 30, T. 26 S., R. 39 E.	Bored	2,423	2,198	225.0	750	Gas	Dom. and stock.
32	L. G. Fairbanks	S. ½ Sec. 24, T. 26 S., R. 38 E.	Bored	2,460	2,180	280.0		Gas	Irrigation.
33	—— Ulrey	N. ½ Sec. 25, T. 26 S., R. 39 E.	Bored 24 inches	2,310	2,156	154.5		None	None.
34	S. A. Arbothnot	S. ½ Sec. 19, T. 26 S., R. 40 E.	Bored 14 inches	2,282	2,154	127.8	263	None	None.
35	Lindsey Bros.	N. ½ Sec. 31, T. 26 S., R. 40 E.	Bored 24 inches	2,325	2,161	164.2		None	None.
36	Frank Wire	W. ½ Sec. 22, T. 26 S., R. 40 E.	Bored 12 inches	2,215	2,151	64 0		None	None.
37	C. D. Williamson	SW. ¼ Sec. 28, T. 26 S., R. 40 E.	Bored 12 inches	2,285	2,192	93.3	225	Gas	Dom. and stock.
38	Borax Works	E. ½ Sec. 12, T. 25 S., R. 40 E.	Bored 6 inches	2,138	2,132	5.5		Wind	Stock.

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The third profile marked X-Y on Plate II, extends from a point on the railroad about two miles south of Inyokern in a northeast direction to an intersection with the profile from Muerto Siding. The depth of water at the railroad is about 250 feet and decreases to about six feet at the salt grass area near the end of the profile. The difference of the elevation of the water surface is 85 feet in a distance of nine miles, making the average slope nine feet per mile.

It can be said that in the vicinity of Brown and Muerto Siding the depth of water along the 2,400-foot contour, as shown on Plate II, is about 150 feet. Further south the depth increases to 200 feet at a point two miles south of Inyokern. The depth decreases toward the east, rapidly at first and then gradually. Within the area of alkali land the depth is less than eight feet. The slope of the ground water surface is within the 2,400-foot contour varies from a maximum of 20 feet per mile near Inyokern to horizontal beneath the lake bottom.

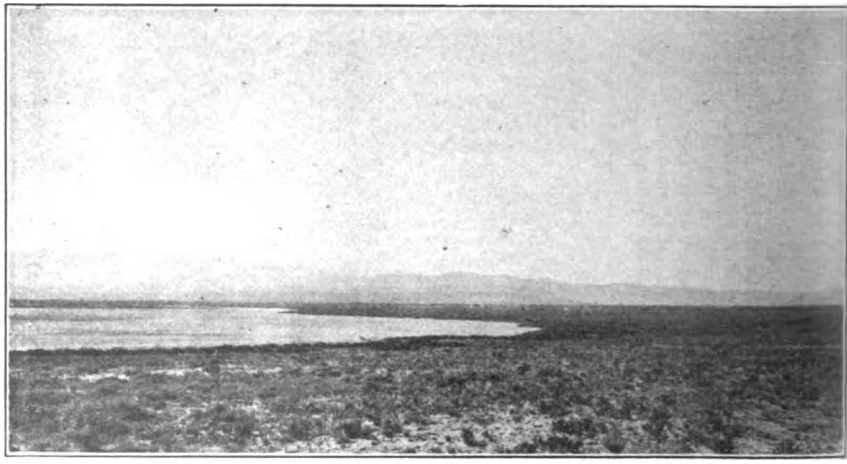

PLATE IV-A.—North arm of China Dry Lake.

The average slope between the 2,400-foot contour and the west edge of the evaporating area is between 9 and 10 feet per mile.

The slope of the ground water surface of this type depends upon the rate at which it receives accretions from the sources of percolating water along the base of the adjacent mountains. When the supply is abundant, as in Owens Valley or San Bernardino Valley, the slopes are steep. For example, opposite Mentone and Redlands in San Bernardino Valley the ground water slope averages 70 feet per mile for several miles, while near Independence in Owens Valley the slope is 90 feet per mile and becomes steeper near the mountains. The ground water basins having abundant water-supply are also characterized by strong flowing springs and cienegas around and in the gently sloping or level portions of their lowest depression. The characteristics of

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abundant ground water supply are all lacking in Indian Wells Valley and thus tend to confirm the earlier conclusions of this study that the supply of ground water is very limited.

The logs of nineteen wells were obtained, some of them from owners but most of them from local well drillers who were very accommodating in furnishing data. None of these wells are situated in T. 25 S., R. 39 E.; six in T. 26 S., R. 39 E.; two in T. 26 S., R. 40 E.; and the other two scattered. The well depths vary from 124 to 339 feet. The logs are all very similar, showing in general a succession of layers of clay and coarse water bearing gravel with occasional layers of fine sand. The per cent of water bearing gravel to the total depth of well varies from 13 to 62 but in most of the wells is about 35 per cent. The gravels are open and coarse and yield water readily. The best water bearing material lies south of the Kern-Inyo boundary, west of the 2,175-foot contour and west of the north and south center line through T. 26 S., R. 40 E. There is a tendency toward fine sands and clays along the center of the depression extending east from Muerto Siding.

Following are the logs from four typical wells:

Well 14: D. W. Shanks, owner; located in northeast quarter of section 4, township 26 south, range 39 east:

Soil and sand, dry	surface to 80 feet
Water bearing gravel	80 to 85 feet
Clay	85 to 95 feet
Water bearing gravel	95 to 105 feet
Clay	105 to 115 feet
Water bearing gravel	115 to 139 feet
Clay	139 to 145 feet
Water bearing gravel	145 to 152 feet
Clay	152 to 157 feet
Water bearing gravel	157 to 162 feet
Clay	162 to 183 feet
Cemented sand	183 to 188 feet
Sandy clay	188 to 198 feet
Clay	198 to 214 feet
Water bearing gravel	214 to 250 feet
Fine sand, water bearing	250 to 265 feet
Water bearing gravel	265 to 292 feet
Cemented sand	292 to 295 feet

Well 3: S. R. Smith, owner; located in northwest quarter of section 19, township 25 south, range 39 east:

Soil, sand and gravel	surface to 160 feet
Water bearing gravel	160 to 180 feet
Clay	180 to 242 feet
Water bearing gravel	242 to 247 feet
Clay	247 to 249 feet
Fine sand	249 to 265 feet
Cemented sand	265 to 269 feet
Water bearing gravel	269 to 272 feet
Clay	272 to 285 feet
Water bearing gravel	285 to 290 feet
Clay	290 to 294 feet
Water bearing gravel	294 to 325 feet
Casing landed in clay.	

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Well 24: W. M. Randall, owner; located in the west half of section 1 ship 25 south, range 39 east:

Soil and sand	surface to 3
Water bearing gravel	33 to 6
Clay	63 to 7
Water bearing gravel	71 to 7
Clay	75 to 9
Water bearing gravel	93 to 10
Clay	101 to 12
Water bearing gravel	120 to 14
Fine sand	145 to 15
Sandy blue clay	155 to 20

Well —: Henry V. Hoffman, owner; located in the east half of s township 26 south, range 40 east:

Soil and hard cemented sand	surface to
Dry gravel	8 to
Cemented sand	50 to
Sand and shale	90 to 12
Sand	124 to 12
Shale	127 to 16
Water bearing sand	164 to 16
Shale	167 to 25
Water bearing gravel	258 to 26

There are eight wells in the valley that have been equipp modern power pumps which are delivering water for irrigat The pumps are of various types, including centrifugal, rotary a well plunger pumps (Plate IV, B). Power is supplied by gas e

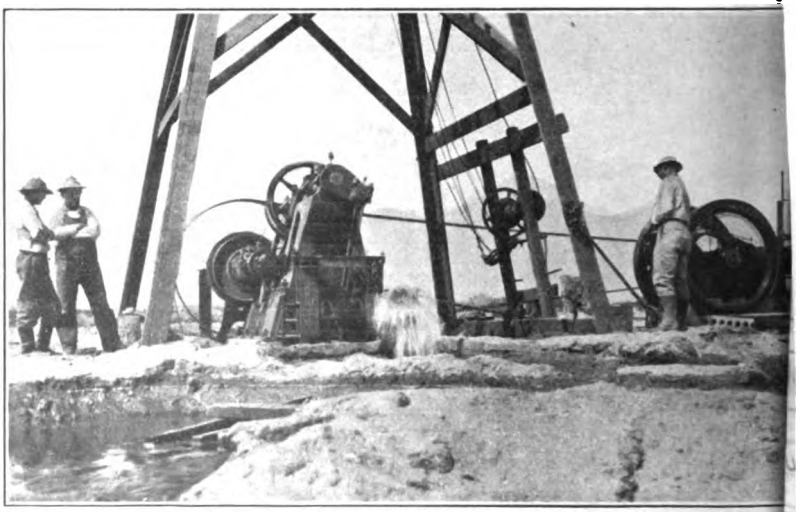

PLATE IV-B.—Pumping plant at Well 1 under test.

at present, but in the near future electricity will be available fro Southern Sierra Power Company, whose transmission line from E Creek to San Bernardino passes through the valley just east railroad. The best wells which have been tested yield less th miner's inches and are reported to have a pumping water level

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20 to 40 feet below normal. None of them yield as much water as is being pumped with the same equipment and lift from wells in regions of more abundant ground water supply. This is probably due to the flat slope of the general ground water surface and the resulting slow movement of ground water toward wells to replace water which is being pumped out. It is a further confirmation of the fact that the water-supply is limited.

The quality of the well waters is excellent for domestic or irrigation use throughout most of the settled portions of the valley. In wells nearer the dry lake, however, the mineral content increases and ground waters beneath the lake are heavily charged with the soluble salts typical of the region. The 2,175-foot contour can be taken as the approximate dividing line between waters which are fit for domestic use and those which cannot thus be used permanently. It is possible that waters pumped from wells as far east as the 2,150-foot contour could be used for irrigating but the ultimate effect would not be beneficial to the plant growth.

CONCLUSIONS.

1. The total volume of water which can be annually pumped from the gravels underlying the agricultural land in the Indian Wells Valley, without permanently lowering the ground water levels, does not exceed 11,000 acre-feet per annum.

2. To develop this amount of water the distance between regularly pumped wells should exceed one and one-half miles and not more than 200 acre-feet per year (50 miner's inches, twelve hours per day for six months) should be pumped from any one well.

3. The best location for wells is between the 2,400 and the 2,175-foot contour of Plate II, west of the north and south center line of T. 26 S., R. 40 E., and south of the Kern-Inyo County line.

4. The total number of acres which can be irrigated by means of this water-supply is about 2,000 acres, and the area which can be irrigated from each well not more than 40 acres.

5. Measurements of the depth to water in typical wells should be made at least annually to determine the effect of pumping upon the water plane.

6. The water supply of Indian Wells Valley is sufficient to irrigate not more than 3 per cent of the agricultural land.

7. Water supply conditions in other desert valleys of southeastern California are similar to those described for Indian Wells Valley.

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EXHIBIT "A."

Data Concerning Timber Holdings in California.

Group 1.

Over 500,000 acres.

Owner.	County.	Acreage.	Total.	Percentage of whole.
S. P. Co.	Yuba	7,400		
	Sierra	73,978		
	Tehama	16,126		
	Siskiyou	277,830		
	Butte	20,840		
	Trinity	145,606		
	Plumas	4,977		
	Shasta	109,850		
	San Bernardino	160		
	Placer	114,004		
	Riverside	26		
	Nevada	50,281	821,078	18
T. B. Walker	Plumas	82,321		
	Tehama	8,945		
	Modoc	135,882		
	Lassen	165,437		
	Siskiyou	88,279		
	Shasta	234,296	715,160	15.7

Group 2.

Over 100,000 acres.

McCloud River Lumber Co.	Siskiyou	152,471		
	Shasta	4,225	156,696	3.44

Group 3.

Over 50,000 acres.

Union Lumber Co.	Mendocino	57,700	57,700	1.27
Hammond Lumber Co.	Humboldt	91,580		
	Del Norte	960	92,540	2.03
C. A. Smith Lumber Co.	Humboldt	29,800		
	El Dorado	46,700	76,500	1.68
Diamond Match Co.	Plumas	5,230		
	Tehama	21,318		
	Butte	24,100		
	Shasta	5,617	56,265	1.23
Curtis, Collins & Holbrook	Tehama	31,599		
	Plumas	31,737	63,336	1.17
Weed Lumber Co.	Plumas	31,737	63,336	1.39
	Siskiyou	53,468	53,468	1.17

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EXHIBIT A—*Continued.*

Group 4.

Over 20,000 acres.

Owner.	County.	Acreage.	Total.	Percentage of whole.
Pennsylvania Lumber Co.	Lassen	29,840	29,840	.66
Manistique Lumber Co.	Modoc	45,923	45,923	1.01
Del Norte Co.	Del Norte	23,920	23,920	.53
W. E. Wheeler	Butte	19,537		
	Plumas	21,939	41,476	.91
Standard Lumber Co.	Tuolumne	26,080	26,080	.57
White & Friant Lumber Co.	Tuolumne	6,460		
	Madera	12,840		
	Mariposa	2,080	21,380	.47
West Side Lumber Co.	Tuolumne	39,590	39,590	.87
Charles A. Ruggles	Calaveras	37,840	37,840	.82
Michigan Trust Co.	Modoc	15,798		
	Mendocino	8,000	23,798	.52
New York & Penn. Redwood Co.	Mendocino	20,600	20,600	.45
Mendocino Lumber Co.	Mendocino	21,488	21,488	.47
Vance Redwood Lumber Co.	Humboldt	17,950		
	Del Norte	6,800	24,750	.54
Sierra Nevada Wood & Lbr. Co.	Sierra	35,308		
	Placer	560	36,308	.80
Roberts Lumber Co.	Sierra	3,240		
		440		
	Plumas	24,682	27,922	.61
E. B. Perrin	Tehama	31,755	31,755	.70
Pacific Coast Redwood Co.	Mendocino	37,280	37,280	.82
Sage Land Improvement Co.	Mendocino	30,080		
	Humboldt	18,640	48,720	1.07
L. E. White Lumber Co.	Mendocino	30,960	30,960	.68
Desert Redwood Co.	Humboldt	22,430	22,430	.49
Pacific Lumber Co.	Humboldt	46,220	46,220	1.02
J. E. Henry & Sons	Humboldt	32,880	32,880	.72

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EXHIBIT A—*Continued.*

Group 5.

Over 15,000 acres.

Owner.	County.	Acreage.	Total.
Isaac Minor	Tuolumne	10,500	
	Mariposa	7,020	17,5
Empire Redwood Co.	Mendocino	6,080	
	Sonoma	10,245	16,3
Scott Graff	Lassen	18,065	18,0
Truckee Lumber Co.	Butte	13,250	
	Plumas	3,080	16,3
Fruit Growers' Supply Co.	Siskiyou	14,650	
	Shasta	1,400	16,0
El Sur Rancho	Monterey	17,528	17,5
Brown Bros. Lumber Co.	Calaveras	12,920	
	Amador	3,840	16,7
Dempsey, Piler & Wentz	Modoc	16,216	16,2
Sionseta Lumber Co.	Modoc	17,910	17,9
Warren Timber Co.	Humboldt	15,000	15,0
Northern Redwood Lumber Co.	Humboldt	17,600	17,6
Soper Wheeler	Shasta	4,674	
	Plumas	7,631	
	Butte	3,860	
	Yuba	1,960	18,1
Casper Lumber Co.	Mendocino	16,260	16,2
North Coast Development Co.	Mendocino	15,340	15,3
A. H. Flemming	Mendocino	16,420	
	Madera	2,720	19,1
John McAlpine	Lassen	8,450	
	Sierra	2,680	
	Shasta	200	
	Plumas	640	
	Tehama	4,038	16,0
Hotchkiss Timber Co.	Del Norte	18,660	18,6
Hobbs-Wall Co.	Del Norte	15,920	15,9

Group 6.

Over 10,000 acres.

Wheeler Timber Co.	Sonoma	5,490	
	Mendocino	7,680	13,1
A. J. Hardon Estate	Mendocino	10,600	10,6
Southern Humboldt Lumber Co.	Mendocino	12,160	
	Humboldt	240	12,4
Thomas Blair	Humboldt	11,520	11,5
Merryman Fruit, Land & Lumber Co.	Humboldt	11,120	11,1
R. B. Whiteside	Tuolumne	10,560	
	Calaveras	1,840	12,4
H. C. Ward et al.	Del Norte	5,200	
	Humboldt	8,640	13,8
Silver Fork Lumber Co.	El Dorado	11,960	11,9
Baker, Piler, Dempsey & Wentz	Modoc	10,447	10,4
Warde, W. C., F. B. & F. L.	Del Norte	12,440	12,4
Northwestern Redwood Co.	Mendocino	10,060	10,0
McArthur & Ducey	Tuolumne	10,880	10,8
Glen Blair Lumber Co.	Mendocino	10,620	10,6
Fresno Flume & Lumber Co.	Fresno	11,623	11,6
Mendenhall Cattle Co.	San Diego	13,740	13,7
Mono Lake R. R. Co.	Mono	14,400	14,4
Lagunitas Water Co.	Marin	11,597	11,5
Madera Sugar Pine Co.	Mariposa	9,080	
	Madera	3,256	12,3
Power Lumber Co.	Placer	10,899	10,8
Read Timber Lumber Co.	Placer	10,000	10,0

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EXHIBIT A—*Continued.*

Group 7.

Over 5,000 acres.

Owner.	County.	Acreage.	Total.	Percentage of whole.
El Dorado Lumber Co.	El Dorado	8,920	8,920	.20
Irvine Muir Lumber Co.	Mendocino	7,230	7,230	.16
Sunset Trading & Land Co.	Mendocino	5,920	5,920	.13
Rose, L. B.	Mendocino	5,080	5,080	.11
McPherson, R., et al.	Mendocino	6,760	6,760	.15
Reno Mills & Lumber Co.	Plumas	5,225	5,225	.11
Hooker, J. H.	Humboldt	5,120	5,120	.11
Dolbeer, Carson Lumber Co.	Humboldt	8,510	8,510	.19
McClure Land Co.	Humboldt	6,720	6,720	.15
Weston, B. F.	Calaveras	6,000	6,000	.13
Pacific Improvement Co.	Shasta	4,450		
	Placer	1,160	5,610	.12
Floriston Pulp & Paper Co.	Placer	5,280	5,280	.12
Yosemite Lumber Co.	Mariposa	7,600	7,600	.17
Roe Burgass Land Co.	Siskiyou	1,769		
	Modoc	5,776	7,545	.17
Foster Co.	Mendocino	5,240	5,240	.12
Stearns Lumber Co.	Mendocino	6,040	6,040	.13
Consolidated Redwood Co.	Mendocino	5,600	5,600	.12
Albion Lumber Co.	Mendocino	7,700	7,700	.17
Northwest Land Co.	Humboldt	6,160	6,160	.14
Mitchell, Dorr Realty Co.	Humboldt	9,960	9,960	.22
Hicks Vaughn Redwood Co.	Humboldt	5,440	5,440	.12
Hume Bennett Lumber Co.	Fresno	5,280		
	Tulare	320	5,600	.12
Fleitz, George F.	Tulare	8,940	8,940	.20
Five States Lumber Co.	Siskiyou	9,080		
	Shasta	486	9,566	.21
Amador Lumber Co.	El Dorado	240		
	Amador	8,013	8,253	.18
Santa Cruz Lime Co.	Santa Cruz	6,982	6,982	.15
McRae, Donald	Tulare	8,680	8,680	.19
Greenwald, Levi & Co.	Tulare	5,240		
	Plumas	2,148		
	Yuba	2,400	9,788	.22
The A. Brown Co.	Tulare	1,960		
	Glenn	1,400		
	Kern	3,840	7,200	.16
Riley, H. B., & Niblack, W. C.	Glenn	8,256	8,256	.18
Bear Valley Mutual Co.	San Bernardino	5,257	5,257	.12
Kern County Land Co.	Kern	4,760	4,760	.12
	Ventura	803	5,563	
Hopkins, Emily B.	Sonoma	5,836	5,836	.13
Briggs, Frank & Hiram	Sonoma	5,640	5,640	.12
Kern, William, et al.	Lassen	6,110	6,110	.13
Cone Ranch Co.	Lassen	5,152	5,152	.11
Boca Mills Lumber Co.	Sierra	5,120	5,120	.11
Algorna Lumber Co.	Siskiyou	5,120	5,120	.11
Roberts, E. C.	Siskiyou	9,000	9,000	.20
Winton Lumber Co.	Siskiyou	6,960	6,960	.15
Allen, A. M., et al.	Monterey	9,021	9,021	.20

Group 8.

Under 5,000 acres.

Holdings of a large number of small owners, 971,580 acres.....21.33% of all

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EXHIBIT D.

School Land Data.

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912
Sec. 16, T. 16 N., R. 1 E., H.	Surveyed		156.29	156.29
Sec. 36, T. 16 N., R. 1 E., H.	Surveyed		160	160
Sec. 36, T. 18 N., R. 1 E., H.	Surveyed	440		440
Sec. 36, T. 5 N., R. 2 E., H.	Surveyed		120	120
Sec. 36, T. 17 N., R. 2 E., H.	Surveyed	320		320
Sec. 36, T. 19 N., R. 2 E., H.	Surveyed	304.38		304.38
Sec. 36, T. 4 N., R. 3 E., H.	Surveyed		160	160
Sec. 36, T. 8 N., R. 3 E., H.	Surveyed	40		40
Sec. 16, T. 14 N., R. 3 E., H.	Surveyed	600		600
Sec. 36, T. 14 N., R. 3 E., H.	Surveyed	160		160
Sec. 36, T. 15 N., R. 3 E., H.	Surveyed	240		240
Sec. 16, T. 17 N., R. 3 E., H.	Surveyed	420.34		420.34
Sec. 16, T. 18 N., R. 3 E., H.	Surveyed	6.65		6.65
Sec. 36, T. 18 N., R. 3 E., H.	Surveyed	15.17		15.17
Sec. 36, T. 5 N., R. 4 E., H.	Surveyed		360	360
Sec. 16, T. 11 N., R. 4 E., H.	Surveyed	111.88		111.88
Sec. 16, T. 14 N., R. 4 E., H.	Surveyed	239.51		239.51
Sec. 36, T. 14 N., R. 4 E., H.	Surveyed	260		260
Sec. 16, T. 15 N., R. 4 E., H.	Surveyed	640		640
Sec. 36, T. 15 N., R. 4 E., H.	Surveyed	80		80
Sec. 16, T. 16 N., R. 4 E., H.	Surveyed	120		120
Sec. 36, T. 16 N., R. 4 E., H.	Surveyed	240		240
Sec. 36, T. 17 N., R. 4 E., H.	Surveyed	9.02		9.02
Sec. 16, T. 18 N., R. 4 E., H.	Surveyed	137.04		137.04
Sec. 36, T. 18 N., R. 4 E., H.	Surveyed	51.94		51.94
Sec. 36, T. 19 N., R 4 E., H.	Surveyed		640	640
Sec. 16, T. 1 N., R. 5 E., H.	Surveyed		80	80
Sec. 36, T. 3 N., R. 5 E., H.	Surveyed	487.76		487.76
Sec. 16, T. 4 N., R. 5 E., H.	Surveyed	480		480
Sec. 16, T. 6 N., R. 5 E., H.	Surveyed	120		120
Sec. 36, T. 3 N., R. 6 E., H.	Surveyed	160		160
Sec. 16, T. 4 N., R. 6 E., H.	Surveyed	19.62		19.62
Sec. 36, T. 4 N., R. 6 E., H.	Surveyed	120		120
Sec. 16, T. 6 N., R. 6 E., H.	Surveyed	42.25		42.25
Sec. 36, T. 6 N., R. 6 E., H.	Surveyed	120		120
Sec. 16, T. 7 N., R. 6 E., H.	Surveyed	640		640
Sec. 36, T. 7 N., R. 6 E., H.	Surveyed	6.60		6.60
Sec. 16, T. 8 N., R. 6 E., H.	Surveyed	80		80
Sec. 16, T. 9 N., R. 6 E., H.	Surveyed	7.07		7.07
Sec. 36, T. 9 N., R. 6 E., H.	Surveyed	80		80
Sec. 16, T. 10 N., R. 6 E., H.	Surveyed	400		400
Sec. 16, T. 13 N., R. 6 E., H.	Surveyed	80		80
Sec. 36, T. 13 N., R. 6 E., H.	Surveyed	80		80
Sec. 16, T. 15 N., R. 6 E., H.	Surveyed	97.27		97.27
Sec. 16, T. 16 N., R. 6 E., H.	Surveyed	446.71		446.71
Sec. 36, T. 16 N., R. 6 E., H.	Surveyed	560		560
Sec. 36, T. 17 N., R. 6 E., H.	Surveyed	80		80
Sec. 16, T. 7 N., R. 5 E., H.	Surveyed	322.14		322.14
Sec. 36, T. 9 N., R. 5 E., H.	Surveyed	160		160
Sec. 36, T. 10 N., R. 5 E., H.	Surveyed	10.12		10.12
Sec. 36, T. 11 N., R. 5 E., H.	Surveyed	6.87		6.87
Sec. 16, T. 12 N., R. 5 E., H.	Surveyed	1.75		1.75
Sec. 16, T. 13 N., R. 5 E., H.	Surveyed	160		160
Sec 16, T. 13 N., R. 5 E., H.	Surveyed	80		80
Sec. 16, T. 14 N., R. 5 E., H.	Surveyed	75.79		75.79
Sec. 36, T. 14 N., R. 5 E., H.	Surveyed	40		40
Sec 16, T. 15 N., R. 5 E., H.	Surveyed	40		40
Sec 36, T. 15 N., R. 5 E., H.	Surveyed	30.77		30.77
Sec 16, T. 16 N., R. 5 E., H.	Surveyed	80		80

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 16 N., R. 5 E., H.	Surveyed	250		250
Sec. 36, T. 18 N., R. 5 E., H.	Surveyed	95		95
Sec 36, T. 19 N., R. 5 E., H.	Surveyed	1.32		1.32
Sec 36, T. 1 N., R. 6 E., H.	Surveyed	160		160
Sec. 36, T. 2 N., R. 6 E., H.	Surveyed	80.91		80.91
Sec. 36, T. 18 N., R. 6 E., H.	Surveyed	40.08		40.08
Sec. 16, T. 3 N., R. 7 E., H.	Surveyed	400		400
Sec. 36, T. 3 N., R. 7 E., H.	Surveyed	320		320
Sec. 36, T. 4 N., R. 7 E., H.	Surveyed	170.01		170.01
Sec. 16, T. 5 N., R. 7 E., H.	Surveyed	320		320
Sec. 36, T. 5 N., R. 7 E., H.	Surveyed	320		320
Sec. 16, T. 6 N., R. 7 E., H.	Surveyed	280		280
Sec. 36, T. 6 N., R. 7 E., H.	Surveyed	120		120
Sec. 16, T. 7 N., R. 7 E., H.	Surveyed	560		560
Sec. 16, T. 8 N., R. 7 E., H.	Surveyed	560		560
Sec. 36, T. 8 N., R. 7 E., H.	Surveyed	207.72		207.72
Sec. 36, T. 9 N., R. 7 E., H.	Surveyed	280		280
Sec. 16, T. 10 N., R. 7 E., H.	Surveyed	20		20
Sec. 36, T. 10 N., R. 7 E., H.	Surveyed	8.97		8.97
Sec. 16, T. 13 N., R. 7 E., H.	Surveyed	80		80
Sec. 16, T. 14 N., R. 7 E., H.	Surveyed	201.71		201.71
Sec. 36, T. 14 N., R. 7 E., H.	Surveyed	80		80
Sec. 16, T. 15 N., R. 7 E., H.	Surveyed	202.30		202.30
Sec. 36, T. 15 N., R. 7 E., H.	Surveyed	480		480
Sec. 16, T. 17 N., R. 7 E., H.	Surveyed	2.25		2.25
Sec. 36, T. 17 N., R. 7 E., H.	Surveyed	160		160
Sec. 36, T. 19 N., R. 7 E., H.	Surveyed	600		600
Sec 16, T. 2 N., R. 1 W., H.	Surveyed		160	160
Sec. 36, T. 7 N., R. 1 W., H.	Surveyed		48	48
Sec 16, T. 5 N., R. 1 W., H.	Surveyed		110	110
Sec. 16, T. 1 S., R. 1 W., H.	Surveyed		120	120
Sec 36. T. 1 S., R. 1 W., H.	Surveyed		320	320
Sec. 16, T. 3 S., R. 1 W., H.	Surveyed		160	160
Sec. 36, T. 3 S., R. 1 W., H.	Unsurveyed		640	640
Sec. 36, T. 1 S., R. 3 W., H.	Surveyed		44.98	44.98
Sec. 16, T. 2 S., R. 1 E., H.	Surveyed		160	160
Sec. 36, T. 3 S., R. 1 E., H.	Surveyed		40	40
Sec. 16, T. 4 S., R. 1 E., H.	Unsurveyed		560	560
Sec. 16, T. 5 S., R. 3 E., H.	Surveyed		80	80
Sec. 16, T. 5 S., R. 4 E., H.	Surveyed		320	320
Sec. 36, T. 5 S., R. 4 E., H.	Surveyed		320	320
Sec. 36, T. 5 S., R. 5 E., H.	Surveyed		400	400
Sec. 36, T. 1 S., R. 6 E., H.	Surveyed	560		560
Sec. 36, T. 3 S., R. 6 E., H.	Surveyed		320	320
Sec. 16, T. 2 S., R. 7 E., H.	Surveyed	280		280
Sec. 36, T. 2 S., R. 7 E., H.	Surveyed	440		440
Sec. 36, T. 3 S., R. 7 E., H.	Surveyed	360		360
Sec. 16, T. 4 S., R. 7 E., H.	Surveyed		240	240
Sec. 36, T. 4 S., R. 7 E., H.	Surveyed	640		640
Sec. 16, T. 3 S., R. 8 E., H.	Surveyed	514.57		514.57
Sec. 16, T. 5 S., R. 8 E., H.	Surveyed		80.66	80.66
Sec. 16, T. 1 N., R. 1 E., M. D.	Surveyed		560	560
Sec. 36, T. 3 N., R. 1 E., M. D.	Surveyed		38.79	38.79
Sec. 16, T. 7 N., R. 1 E., M. D.	Surveyed		320	320
Sec. 36, T. 7 N., R. 1 E., M. D.	Surveyed		640	640
Sec. 36, T. 11 N., R. 1 E., M. D.	Surveyed		320	320
Sec. 36, T. 12 N., R. 1 E., M. D.	Surveyed		120	120
Sec. 36, T. 13 N., R. 1 E., M. D.	Surveyed		29.53	29.53
Sec. 16, T. 15 N., R. 1 E., M. D.	Surveyed		173.15	173.15
Sec. 36, T. 15 N., R. 1 E., M. D.	Surveyed		43.26	43.26

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912
Sec. 16, T. 16 N., R. 1 E., M. D.	Surveyed		160	160
Sec. 36, T. 27 N., R. 1 E., M. D.	Surveyed		640	640
Sec. 36, T. 28 N., R. 1 E., M. D.	Surveyed		40	40
Sec. 36, T. 36 N., R. 1 E., M. D.	Surveyed		324.24	324.24
Sec. 36, T. 41 N., R. 1 E., M. D.	Surveyed		280	280
Sec. 16, T. 42 N., R. 1 E., M. D.	Surveyed		640	640
Sec. 36, T. 43 N., R. 1 E., M. D.	Surveyed	640		640
Sec. 36, T. 45 N., R. 1 E., M. D.	Surveyed	640		640
Sec. 36, T. 47 N., R. 1 E., M. D.	Surveyed		400	400
Sec. 16, T. 48 N., R. 1 E., M. D.	Surveyed		168.39	168.39
Sec. 16, T. 4 N., R. 2 E., M. D.	Surveyed		320	320
Sec. 36, T. 6 N., R. 2 E., M. D.	Surveyed		13.25	13.25
Sec. 16, T. 7 N., R. 2 E., M. D.	Surveyed		160	160
Sec. 36, T. 7 N., R. 2 E., M. D.	Surveyed		640	640
Sec. 36, T. 8 N., R. 2 E., M. D.	Surveyed		320	320
Sec. 36, T. 11 N., R. 2 E., M. D.	Surveyed		160	160
Sec. 16, T. 12 N., R. 2 E., M. D.	Surveyed		600	600
Sec. 16, T. 14 N., R. 2 E., M. D.	Surveyed		240	240
Sec. 36, T. 15 N., R. 2 E., M. D.	Surveyed		320	320
Sec. 36, T. 23 N., R. 2 E., M. D.	Surveyed		200	200
Sec. 16, T. 24 N., R. 2 E., M. D.	Surveyed		640	640
Sec. 16, T. 26 N., R. 2 E., M. D.	Surveyed	640		640
Sec. 36, T. 36 N., R. 2 E., M. D.	Surveyed		140	140
Sec. 16, T. 42 N., R. 2 E., M. D.	Surveyed	80		80
Sec. 36, T. 43 N., R. 2 E., M. D.	Unsurveyed	640		640
Sec. 16, T. 45 N., R. 2 E., M. D.	Surveyed	80		80
Sec. 36, T. 46 N., R. 2 E., M. D.	Surveyed		360	360
Sec. 16, T. 47 N., R. 2 E., M. D.	Surveyed		234.09	234.09
Sec. 36, T. 2 N., R. 3 E., M. D.	Surveyed		.78	.78
Sec. 16, T. 3 N., R. 3 E., M. D.	Unsurveyed		.61	.61
Sec. 16, T. 4 N., R. 3 E., M. D.	Unsurveyed		6.43	6.43
Sec. 36, T. 5 N., R. 3 E., M. D.	Unsurveyed		15.57	15.57
Sec. 16, T. 6 N., R. 3 E., M. D.	Surveyed		40	40
Sec. 16, T. 8 N., R. 3 E., M. D.	Surveyed		640	640
Sec. 16, T. 11 N., R. 3 E., M. D.	Surveyed		1.32	1.32
Sec. 36, T. 24 N., R. 3 E., M. D.	Surveyed		29.79	29.79
Sec. 16, T. 26 N., R. 3 E., M. D.	Surveyed		640	640
Sec. 16, T. 28 N., R. 3 E., M. D.	Surveyed		640	640
Sec. 36, T. 29 N., R. 3 E., M. D.	Surveyed	40		40
Sec. 36, T. 30 N., R. 3 E., M. D.	Unsurveyed	1.22		1.22
Sec. 16, T. 37 N., R. 3 E., M. D.	Surveyed		160	160
Sec. 36, T. 41 N., R. 3 E., M. D.	Unsurveyed	.32		.32
Sec. 16, T. 43 N., R. 3 E., M. D.	Surveyed	640		640
Sec. 36, T. 43 N., R. 3 E., M. D.	Surveyed	60		60
Sec. 36, T. 44 N., R. 3 E., M. D.	Surveyed	560		560
Sec. 16, T. 45 N., R. 3 E., M. D.	Surveyed		640	640
Sec. 36, T. 45 N., R. 3 E., M. D.	Surveyed		640	640
Sec. 16, T. 46 N., R. 3 E., M. D.	Unsurveyed		40	40
Sec. 36, T. 46 N., R. 3 E., M. D.	Unsurveyed		2.47	2.47
Sec. 16, T. 47 N., R. 3 E., M. D.	Surveyed		81	81
Sec. 16, T. 1 N., R. 4 E., M. D.	Unsurveyed		.48	.48
Sec. 36, T. 2 N., R. 4 E., M. D.	Unsurveyed		.82	.82
Sec. 36, T. 4 N., R. 4 E., M. D.	Unsurveyed		1.62	1.62
Sec. 36, T. 5 N., R. 4 E., M. D.	Surveyed		5.16	5.16
Sec. 16, T. 9 N., R. 4 E., M. D.	Surveyed		6.05	6.05
Sec. 36, T. 10 N., R. 4 E., M. D.	Surveyed		160	160
Sec. 36, T. 21 N., R. 4 E., M. D.	Surveyed		240	240
Sec. 16, T. 27 N., R. 4 E., M. D.	Surveyed	640		640
Sec. 16, T. 29 N., R. 4 E., M. D.	Surveyed	16.36		16.36
Sec. 36, T. 30 N., R. 4 E., M. D.	Surveyed	40		40

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 32 N., R. 4 E., M. D.	Surveyed	35.74		35.74
Sec. 36, T. 34 N., R. 4 E., M. D.	Surveyed	200		200
Sec. 16, T. 36 N., R. 4 E., M. D.	Surveyed		40	40
Sec. 36, T. 36 N., R. 4 E., M. D.	Surveyed		640	640
Sec. 36, T. 37 N., R. 4 E., M. D.	Surveyed		120	120
Sec. 16, T. 41 N., R. 4 E., M. D.	Surveyed	640		640
Sec. 16, T. 42 N., R. 4 E., M. D.	Surveyed	640		640
Sec. 36, T. 42 N., R. 4 E., M. D.	Surveyed	40.56		40.56
Sec. 16, T. 45 N., R. 4 E., M. D.	Surveyed		640	640
Sec. 36, T. 45 N., R. 4 E., M. D.	Surveyed		360	360
Sec. 16, T. 46 N., R. 4 E., M. D.	Surveyed		259.36	259.36
Sec. 16, T. 47 N., R. 4 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 1 N., R. 5 E., M. D.	Surveyed		3.83	3.83
Sec. 16, T. 3 N., R. 5 E., M. D.	Surveyed		80	80
Sec. 16, T. 4 N., R. 5 E., M. D.	Surveyed		250.31	250.31
Sec. 36, T. 4 N., R. 5 E., M. D.	Surveyed		640	640
Sec. 36, T. 5 N., R. 5 E., M. D.	Surveyed		280	280
Sec. 36, T. 6 N., R. 5 E., M. D.	Surveyed		.25	.25
Sec. 16, T. 8 N., R. 5 E., M. D.	Surveyed		40	40
Sec. 36, T. 8 N., R. 5 E., M. D.	Surveyed		480	480
Sec. 16, T. 19 N., R. 5 E., M. D.	Surveyed		.04	.04
Sec. 36, T. 19 N., R. 5 E., M. D.	Surveyed		18.23	18.23
Sec. 16, T. 20 N., R. 5 E., M. D.	Surveyed		480	480
Sec. 16, T. 21 N., R. 5 E., M. D.	Surveyed	54.95		54.95
Sec. 36, T. 21 N., R. 5 E., M. D.	Surveyed		240	240
Sec. 16, T. 23 N., R. 5 E., M. D.	Surveyed	15		15
Sec. 16, T. 25 N., R. 5 E., M. D.	Surveyed	40		40
Sec. 16, T. 31 N., R. 5 E., M. D.	Surveyed	.70		.70
Sec. 36, T. 31 N., R. 5 E., M. D.	Surveyed	4.80		4.80
Sec. 16, T. 32 N., R. 5 E., M. D.	Surveyed	40		40
Sec. 16, T. 33 N., R. 5 E., M. D.	Surveyed	120		120
Sec. 36, T. 33 N., R. 5 E., M. D.	Surveyed	162.48		162.48
Sec. 16, T. 34 N., R. 5 E., M. D.	Surveyed		80	80
Sec. 16, T. 35 N., R. 5 E., M. D.	Surveyed		460	460
Sec. 16, T. 36 N., R. 5 E., M. D.	Surveyed		640	640
Sec. 36, T. 36 N., R. 5 E., M. D.	Surveyed		520	520
Sec. 16, T. 39 N., R. 5 E., M. D.	Surveyed		200	200
Sec. 36, T. 39 N., R. 5 E., M. D.	Surveyed	320		320
Sec. 36, T. 42 N., R. 5 E., M. D.	Surveyed	121.44		121.44
Sec. 16, T. 45 N., R. 5 E., M. D.	Surveyed		640	640
Sec. 36, T. 45 N., R. 5 E., M. D.	Surveyed		640	640
Sec. 16, T. 2 N., R. 6 E., M. D.	Surveyed		160	160
Sec. 36, T. 4 N., R. 6 E., M. D.	Surveyed		9.87	9.87
Sec. 16, T. 18 N., R. 6 E., M. D.	Surveyed		160	160
Sec. 36, T. 18 N., R. 6 E., M. D.	Surveyed		40	40
Sec. 16, T. 20 N., R. 6 E., M. D.	Surveyed		320	320
Sec. 16, T. 25 N., R. 6 E., M. D.	Unsurveyed	640		640
Sec. 36, T. 26 N., R. 6 E., M. D.	Surveyed	.30		.30
Sec. 16, T. 29 N., R. 6 E., M. D.	Surveyed	40		40
Sec. 16, T. 31 N., R. 6 E., M. D.	Surveyed	.45		.45
Sec. 36, T. 31 N., R. 6 E., M. D.	Surveyed	160		160
Sec. 36, T. 32 N., R. 6 E., M. D.	Surveyed	320		320
Sec. 36, T. 35 N., R. 6 E., M. D.	Surveyed	14.34		14.34
Sec. 36, T. 36 N., R. 6 E., M. D.	Surveyed	640		640
Sec. 16, T. 38 N., R. 6 E., M. D.	Surveyed	280		280
Sec. 16, T. 40 N., R. 6 E., M. D.	Surveyed	40		40
Sec. 36, T. 40 N., R. 6 E., M. D.	Surveyed	40		40
Sec. 16, T. 43 N., R. 6 E., M. D.	Surveyed	640		640
Sec. 36, T. 43 N., R. 6 E., M. D.	Surveyed	640		640
Sec. 16, T. 44 N., R. 6 E., M. D.	Surveyed		480	480

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1913.
Sec. 36, T. 45 N., R. 6 E., M. D.	Surveyed		520	520
Sec. 16, T. 46 N., R. 6 E., M. D.	Surveyed		160	160
Sec. 36, T. 46 N., R. 6 E., M. D.	Surveyed		640	640
Sec. 36, T. 47 N., R. 6 E., M. D.	Surveyed		640	640
Sec. 16, T. 48 N., R. 6 E., M. D.	Surveyed		146.13	146.13
Sec. 36, T. 2 N., R. 7 E., M. D.	Surveyed		160	160
Sec. 16, T. 3 N., R. 7 E., M. D.	Surveyed		1.18	1.18
Sec. 36, T. 3 N., R. 7 E., M. D.	Surveyed		640	640
Sec. 36, T. 14 N., R. 7 E., M. D.	Surveyed		40	40
Sec. 16, T. 18 N., R. 7 E., M. D.	Surveyed		329.84	329.84
Sec. 16, T. 23 N., R. 7 E., M. D.	Surveyed	2.93		2.93
Sec. 16, T. 25 N., R. 7 E., M. D.	Unsurveyed	200		200
Sec. 16, T. 26, N., R. 7 E., M. D.	Surveyed	480		480
Sec. 16, T. 31 N., R. 7 E., M. D.	Surveyed	42.96		42.96
Sec. 36, T. 35 N., R. 7 E., M. D.	Surveyed		480	480
Sec. 36, T. 36 N., R. 7 E., M. D.	Surveyed		640	640
Sec. 36, T. 37 N., R. 7 E., M. D.	Surveyed		200	200
Sec. 16, T. 39 N., R. 7 E., M. D.	Surveyed		360	360
Sec. 16, T. 40 N., R. 7 E., M. D.	Surveyed	560		560
Sec. 16, T. 45 N., R. 7 E., M. D.	Surveyed		480	480
Sec. 16, T. 46 N., R. 7 E., M. D.	Surveyed		208.80	208.80
Sec. 36, T. 46 N., R. 7 E., M. D.	Surveyed		368.80	368.80
Sec. 16, T. 47 N., R. 7 E., M. D.	Surveyed		320	320
Sec. 36, T. 47 N., R. 7 E., M. D.	Surveyed		520	520
Sec. 16, T. 48 N., R. 7 E., M. D.	Surveyed		163.58	163.58
Sec. 36, T. 48 N., R. 7 E., M. D.	Surveyed		480	480
Sec. 36, T. 1 N., R. 8 E., M. D.	Surveyed		160	160
Sec. 16, T. 2 N., R. 8 E., M. D.	Surveyed		160	160
Sec. 36, T. 11 N., R. 8 E., M. D.	Surveyed		160	160
Sec. 16, T. 15 N., R. 8 E., M. D.	Surveyed		320	320
Sec. 36, T. 19 N., R. 8 E., M. D.	Surveyed	480		480
Sec. 36, T. 20 N., R. 8 E., M. D.	Surveyed	175.19		175.19
Sec. 16, T. 23 N., R. 8 E., M. D.	Surveyed	640		640
Sec. 36, T. 23 N., R. 8 E., M. D.	Surveyed	160		160
Sec. 36, T. 24 N., R. 8 E., M. D.	Surveyed	.07		.07
Sec. 36, T. 28 N., R. 8 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 31 N., R. 8 E., M. D.	Surveyed	40		40
Sec. 16, T. 33 N., R. 8 E., M. D.	Surveyed	13.87		13.87
Sec. 16, T. 34 N., R. 8 E., M. D.	Surveyed	360		360
Sec. 16, T. 35 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 36, T. 35 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 16, T. 36 N., R. 8 E., M. D.	Surveyed	640		640
Sec. 36, T. 36 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 16, T. 37 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 16, T. 38 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 36, T. 38 N., R. 8 E., M. D.	Surveyed	400		400
Sec. 16, T. 40 N., R. 8 E., M. D.	Surveyed	120		120
Sec. 16, T. 41 N., R. 8 E., M. D.	Surveyed	640		640
Sec. 16, T. 44 N., R. 8 E., M. D.	Unsurveyed	80		80
Sec. 36, T. 44 N., R. 8 E., M. D.	Unsurveyed	40		40
Sec. 36, T. 46 N., R. 8 E., M. D.	Surveyed		640	640
Sec. 16, T. 48 N., R. 8 E., M. D.	Surveyed		73.96	73.96
Sec. 16, T. 9 N., R. 9 E., M. D.	Surveyed		120	120
Sec. 16, T. 10 N., R. 9 E., M. D.	Surveyed		400	400
Sec. 36, T. 15 N., R. 9 E., M. D.	Surveyed		40	40
Sec. 36, T. 19 N., R. 9 E., M. D.	Surveyed	190.79		190.79
Sec. 36, T. 20 N., R. 9 E., M. D.	Unsurveyed	40.22		40.22
Sec. 36, T. 21 N., R. 9 E., M. D.	Surveyed	640		640
Sec. 16, T. 22 N., R. 9 E., M. D.	Surveyed	640		640
Sec. 16, T. 27 N., R. 9 E., M. D.	Surveyed	80		80

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 30 N., R. 9 E., M. D.	Surveyed	560		560
Sec. 36, T. 32 N., R. 9 E., M. D.	Surveyed	3.18		3.18
Sec. 16, T. 35 N., R. 9 E., M. D.	Surveyed		560	560
Sec 16, T. 36 N., R. 9 E., M. D.	Surveyed		640	640
Sec 36, T. 36 N., R. 9 E., M. D.	Surveyed		560	560
Sec 16, T. 38 N., R. 9 E., M. D.	Surveyed		160	160
Sec. 36, T. 38 N., R. 9 E., M. D.	Surveyed		320	320
Sec. 36, T. 39 N., R. 9 E., M. D.	Surveyed	40		40
Sec. 36, T. 40 N., R. 9 E., M. D.	Surveyed		440	440
Sec. 16, T. 41 N., R. 9 E., M. D.	Surveyed		360	360
Sec. 36, T. 41 N., R. 9 E., M. D.	Surveyed		560	560
Sec. 16, T. 42 N., R. 9 E., M. D.	Surveyed	280		280
Sec. 36, T. 42 N., R. 9 E., M. D.	Surveyed		40	40
Sec 36, T. 43 N., R. 9 E., M. D.	Surveyed	640		640
Sec. 16, T. 44 N., R. 9 E., M. D.	Surveyed	360		360
Sec. 16, T. 46 N., R. 9 E., M. D.	Surveyed		480	480
Sec. 36, T. 46 N., R. 9 E., M. D.	Surveyed	120		120
Sec. 36, T. 48 N., R. 9 E., M. D.	Surveyed	51		51
Sec. 36, T. 5 N., R. 10 E., M. D.	Surveyed		40	40
Sec. 16, T. 6 N., R. 10 E., M. D.	Surveyed		40	40
Sec. 16, T. 9 N., R. 10 E., M. D.	Surveyed		40	40
Sec. 36, T. 9 N., R. 10 E., M. D.	Surveyed		120.05	120.05
Sec. 16, T. 10 N., R. 10 E., M. D.	Surveyed		22.23	22.23
Sec. 16, T. 12 N., R. 10 E., M. D.	Surveyed		240	240
Sec. 36, T. 12 N., R. 10 E., M. D.	Surveyed		320	320
Sec. 16, T. 14 N., R. 10 E., M. D.	Surveyed		12	12
Sec. 36, T. 14 N., R. 10 E., M. D.	Surveyed		415.77	415.77
Sec. 16, T. 15 N., R. 10 E., M. D.	Surveyed		201.05	201.05
Sec. 36, T. 15 N., R. 10 E., M. D.	Surveyed		40	40
Sec. 36, T. 18 N., R. 10 E., M. D.	Surveyed	5.99		5.99
Sec. 16, T. 22 N., R. 10 E., M. D.	Surveyed	3.21		3.21
Sec. 36, T. 23 N., R. 10 E., M. D.	Surveyed	200		200
Sec. 16, T. 34 N., R. 10 E., M. D.	Surveyed		80	80
Sec. 16, T. 35 N., R. 10 E., M. D.	Surveyed		600	600
Sec. 36, T. 36 N., R. 10 E., M. D.	Surveyed		640	640
Sec. 36, T. 37 N., R. 10 E., M. D.	Surveyed	240		240
Sec. 36, T. 39 N., R. 10 E., M. D.	Surveyed	200		200
Sec. 16, T. 40 N., R. 10 E., M. D.	Surveyed	400		400
Sec. 36, T. 41 N., R. 10 E., M. D.	Surveyed		40	40
Sec. 16, T. 43 N., R. 10 E., M. D.	Surveyed	160		160
Sec. 36, T. 43 N., R. 10 E., M. D.	Surveyed	160		160
Sec. 36, T. 44 N., R. 10 E., M. D.	Surveyed	640		640
Sec. 16, T. 45 N., R. 10 E., M. D.	Surveyed	280		280
Sec. 36, T. 45 N., R. 10 E., M. D.	Surveyed	640		640
Sec. 16, T. 46 N., R. 10 E., M. D.	Surveyed	160		160
Sec. 36, T. 46 N., R. 10 E., M. D.	Surveyed	81.62		81.62
Sec. 16, T. 47 N., R. 10 E., M. D.	Surveyed	200		200
Sec. 36, T. 47 N., R. 10 E., M. D.	Surveyed	.50		.50
Sec. 36, T. 48 N., R. 10 E., M. D.	Surveyed	80		80
Sec. 36, T. 16 N., R. 11 E., M. D.	Surveyed	280		280
Sec. 36, T. 22 N., R. 11 E., M. D.	Unsurveyed	346.26		346.26
Sec. 36, T. 24 N., R. 11 E., M. D.	Surveyed	96.10		96.10
Sec. 16, T. 25 N., R. 11 E., M. D.	Surveyed	40		40
Sec. 36, T. 25 N., R. 11 E., M. D.	Surveyed	27		27
Sec. 36, T. 27 N., R. 11 E., M. D.	Surveyed	640		640
Sec. 36, T. 30 N., R. 11 E., M. D.	Surveyed		40	40
Sec. 16, T. 31 N., R. 11 E., M. D.	Surveyed		160	160
Sec. 16, T. 34 N., R. 11 E., M. D.	Surveyed		640	640
Sec. 36, T. 34 N., R. 11 E., M. D.	Surveyed		600	600
Sec. 36, T. 35 N., R. 11 E., M. D.	Surveyed		320.12	320.12

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 36 N., R. 11 E., M. D.	Surveyed		640	640
Sec. 36, T. 36 N., R. 11 E., M. D.	Surveyed		480	480
Sec. 36, T. 39 N., R. 11 E., M. D.	Surveyed	160		160
Sec. 16, T. 40 N., R. 11 E., M. D.	Surveyed		640	640
Sec. 16, T. 41 N., R. 11 E., M. D.	Surveyed		240	240
Sec. 36, T. 41 N., R. 11 E., M. D.	Surveyed		200	200
Sec. 36, T. 45 N., R. 11 E., M. D.	Surveyed	640		640
Sec. 16, T. 46 N., R. 11 E., M. D.	Surveyed	160		160
Sec. 36, T. 46 N., R. 11 E., M. D.	Surveyed	120		120
Sec. 36, T. 47 N., R. 11 E., M. D.	Surveyed	640		640
Sec. 36, T. 7 N., R. 12 E., M. D.	Surveyed		40	40
Sec. 16, T. 8 N., R. 12 E., M. D.	Surveyed		40	40
Sec. 16, T. 9 N., R. 12 E., M. D.	Surveyed		480	480
Sec. 16, T. 13 N., R. 12 E., M. D.	Surveyed	80		80
Sec. 36, T. 13 N., R. 12 E., M. D.	Surveyed	2.22		2.22
Sec. 36, T. 14 N., R. 12 E., M. D.	Surveyed		80	80
Sec. 16, T. 18 N., R. 12 E., M. D.	Surveyed	80.08		80.08
Sec. 36, T. 20 N., R. 12 E., M. D.	Surveyed	.05		.05
Sec. 36, T. 21 N., R. 12 E., M. D.	Surveyed	.15		.15
Sec. 16, T. 25 N., R. 12 E., M. D.	Surveyed	80		80
Sec. 16, T. 26 N., R. 12 E., M. D.	Surveyed	40		40
Sec. 36, T. 30 N., R. 12 E., M. D.	Surveyed		200	200
Sec. 16, T. 32 N., R. 12 E., M. D.	Surveyed		640	640
Sec. 36, T. 32 N., R. 12 E., M. D.	Surveyed		640	640
Sec. 16, T. 33 N., R. 12 E., M. D.	Surveyed		440	440
Sec 16, T. 34 N., R. 12 E., M. D.	Surveyed		360	360
Sec. 36, T. 34 N., R. 12 E., M. D.	Surveyed		520	520
Sec. 16, T. 38 N., R. 12 E., M. D.	Surveyed	640		640
Sec. 16, T. 39 N., R. 12 E., M. D.	Surveyed		640	640
Sec. 36, T. 39 N., R. 12 E., M. D.	Surveyed		160	160
Sec. 16, T. 40 N., R. 12 E., M. D.	Surveyed		640	640
Sec. 16, T. 41 N., R. 12 E., M. D.	Surveyed		640	640
Sec. 36, T. 42 N., R. 12 E., M. D.	Surveyed		40	40
Sec. 16, T. 43 N., R. 12 E., M. D.	Surveyed	320		320
Sec. 16, T. 46 N., R. 12 E., M. D.	Surveyed	78.06		78.06
Sec. 36, T. 46 N., R. 12 E., M. D.	Surveyed	640		640
Sec. 16, T. 47 N., R. 12 E., M. D.	Surveyed		40	40
Sec. 16, T. 1 N., R. 13 E., M. D.	Surveyed		200	200
Sec. 36, T. 2 N., R. 13 E., M. D.	Surveyed		40	40
Sec. 36, T. 4 N., R. 13 E., M. D.	Surveyed		130	130
Sec. 36, T. 14 N., R. 13 E., M. D.	Surveyed		40	40
Sec. 16, T. 17 N., R. 13 E., M. D.	Surveyed	40		40
Sec. 16, T. 19 N., R. 13 E., M. D.	Surveyed	160		160
Sec. 36, T. 19 N., R. 13 E., M. D.	Surveyed	8		8
Sec. 36, T. 20 N., R. 13 E., M. D.	Surveyed	120		120
Sec. 16, T. 21 N., R. 13 E., M. D.	Surveyed	40		40
Sec. 36, T. 25 N., R. 13 E., M. D.	Surveyed	80		80
Sec. 16, T. 29 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 16, T. 30 N., R. 13 E., M. D.	Surveyed		520	520
Sec. 16, T. 31 N., R. 13 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 31 N., R. 13 E., M. D.	Surveyed		482.64	482.64
Sec. 16, T. 32 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 36, T. 32 N., R. 13 E., M. D.	Surveyed		480	480
Sec. 16, T. 33 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 36, T. 33 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 16, T. 34 N., R. 13 E., M. D.	Surveyed		560	560
Sec. 36, T. 34 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 36, T. 36 N., R. 13 E., M. D.	Surveyed		40	40
Sec. 16, T. 38 N., R. 13 E., M. D.	Surveyed		560	560
Sec. 36, T. 38 N., R. 13 E., M. D.	Surveyed		3.06	3.06

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 40 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 36, T. 40 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 16, T. 43 N., R. 13 E., M. D.	Surveyed	560		560
Sec. 36, T. 43 N., R. 13 E., M. D.	Surveyed		40	40
Sec. 16, T. 44 N., R. 13 E., M. D.	Surveyed		640	640
Sec. 36, T. 44 N., R. 13 E., M. D.	Surveyed		240	240
Sec. 16, T. 3 N., R. 14 E., M. D.	Surveyed		1.12	1.12
Sec. 36, T. 3 N., R. 14 E., M. D.	Surveyed		104.86	104.86
Sec. 36, T. 4 N., R. 14 E., M. D.	Surveyed		200	200
Sec. 16, T. 14 N., R. 14 E., M. D.	Surveyed	240		240
Sec. 36, T. 18 N., R. 14 E., M. D.	Surveyed	448.35		448.35
Sec. 16, T. 22 N., R. 14 E., M. D.	Surveyed	160		160
Sec. 16, T. 25 N., R. 14 E., M. D.	Surveyed	528.78		528.78
Sec. 36, T. 25 N., R. 14 E., M. D.	Surveyed	40		40
Sec. 36, T. 26 N., R. 14 E., M. D.	Surveyed	640		640
Sec. 36, T. 29 N., R. 14 E., M. D.	Surveyed		40	40
Sec. 16, T. 30 N., R. 14 E., M. D.	Surveyed		480	480
Sec. 36, T. 30 N., R. 14 E., M. D.	Surveyed		480	480
Sec. 16, T. 31 N., R. 14 E., M. D.	Surveyed		640	640
Sec. 36, T. 31 N., R. 14 E., M. D.	Surveyed		560	560
Sec. 16, T. 32 N., R. 14 E., M. D.	Surveyed		640	640
Sec. 36, T. 32 N., R. 14 E., M. D.	Surveyed		520	520
Sec. 16, T. 33 N., R. 14 E., M. D.	Surveyed		640	640
Sec. 36, T. 33 N., R. 14 E., M. D.	Surveyed		640	640
Sec. 16, T. 37 N., R. 14 E., M. D.	Surveyed		320	320
Sec. 16, T. 38 N., R. 14 E., M. D.	Surveyed		320	320
Sec. 36, T. 38 N., R. 14 E., M. D.	Surveyed		80	80
Sec. 16, T. 39 N., R. 14 E., M. D.	Surveyed	80		80
Sec. 36, T. 41 N., R. 14 E., M. D.	Surveyed	440		440
Sec. 36, T. 43 N., R. 14 E., M. D.	Surveyed	336.72		336.72
Sec. 36, T. 3 N., R. 15 E., M. D.	Surveyed		31.37	31.37
Sec. 16, T. 4 N., R. 15 E., M. D.	Surveyed		160.04	160.04
Sec. 36, T. 13 N., R. 15 E., M. D.	Surveyed		160	160
Sec. 16, T. 14 N., R. 15 E., M. D.	Surveyed	80		80
Sec. 36, T. 14 N., R. 15 E., M. D.	Surveyed		120.04	120.04
Sec. 16, T. 15 N., R. 15 E., M. D.	Surveyed	80		80
Sec. 36, T. 15 N., R. 15 E., M. D.	Surveyed		6.06	6.06
Sec. 16, T. 16 N., R. 15 E., M. D.	Surveyed	81.61		81.61
Sec. 16, T. 17 N., R. 15 E., M. D.	Surveyed		161.77	161.77
Sec. 16, T. 18 N., R. 15 E., M. D.	Surveyed	1.94		1.94
Sec. 16, T. 19 N., R. 15 E., M. D.	Surveyed	80		80
Sec. 16, T. 21 N., R. 15 E., M. D.	Surveyed		200	200
Sec. 16, T. 23 N., R. 15 E., M. D.	Surveyed		80	80
Sec. 36, T. 24 N., R. 15 E., M. D.	Surveyed	320.38		320.38
Sec. 36, T. 26 N., R. 15 E., M. D.	Surveyed	440		440
Sec. 36, T. 27 N., R. 15 E., M. D.	Surveyed		1	1
Sec. 16, T. 30 N., R. 15 E., M. D.	Surveyed		520	520
Sec. 36, T. 30 N., R. 15 E., M. D.	Surveyed		480	480
Sec. 36, T. 31 N., R. 15 E., M. D.	Surveyed		640	640
Sec. 16, T. 32 N., R. 15 E., M. D.	Surveyed		240	240
Sec. 36, T. 32 N., R. 15 E., M. D.	Surveyed		640	640
Sec. 16, T. 33 N., R. 15 E., M. D.	Surveyed		640	640
Sec. 36, T. 33 N., R. 15 E., M. D.	Surveyed		640	640
Sec. 16, T. 36 N., R. 15 E., M. D.	Surveyed		80	80
Sec. 36, T. 36 N., R. 15 E., M. D.	Surveyed		380	380
Sec. 36, T. 37 N., R. 15 E., M. D.	Surveyed		640	640
Sec. 36, T. 38 N., R. 15 E., M. D.	Surveyed	320		320
Sec. 16, T. 40 N., R. 15 E., M. D.	Surveyed	360		360
Sec. 36, T. 40 N., R. 15 E., M. D.	Unsurveyed	360		360
Sec. 16, T. 42 N., R. 15 E., M. D.	Surveyed	80		80

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 36, T. 43 N., R. 15 E., M. D.	Surveyed		40
Sec. 16, T. 44 N., R. 15 E., M. D.	Surveyed	80	
Sec. 36, T. 44 N., R. 15 E., M. D.	Surveyed		80
Sec. 36, T. 45 N., R. 15 E., M. D.	Surveyed		320
Sec. 16, T. 46 N., R. 15 E., M. D.	Surveyed	360	
Sec. 16, T. 47 N., R. 15 E., M. D.	Surveyed	80	
Sec. 36, T. 47 N., R. 15 E., M. D.	Surveyed		80
Sec. 36, T. 1 N., R. 16 E., M. D.	Surveyed	160	
Sec. 36, T. 2 N., R. 16 E., M. D.	Surveyed	16.09	
Sec. 36, T. 8 N., R. 16 E., M. D.	Surveyed	160	
Sec. 36, T. 10 N., R. 16 E., M. D.	Surveyed	640	
Sec. 16, T. 11 N., R. 16 E., M. D.	Surveyed	40	
Sec. 36, T. 14 N., R. 16 E., M. D.	Surveyed	80	
Sec. 16, T. 17 N., R. 16 E., M. D.	Surveyed	80	
Sec. 36, T. 18 N., R. 16 E., M. D.	Surveyed		320
Sec. 36, T. 21 N., R. 16 E., M. D.	Surveyed	8.65	
Sec. 16, T. 22 N., R. 16 E., M. D.	Surveyed		320
Sec. 36, T. 23 N., R. 16 E., M. D.	Surveyed		80
Sec. 36, T. 25 N., R. 16 E., M. D.	Surveyed	520	
Sec. 16, T. 29 N., R. 16 E., M. D.	Surveyed		320
Sec. 36, T. 29 N., R. 16 E., M. D.	Surveyed		640
Sec. 16, T. 30 N., R. 16 E., M. D.	Surveyed		640
Sec. 36, T. 30 N., R. 16 E., M. D.	Surveyed		640
Sec. 16, T. 31 N., R. 16 E., M. D.	Surveyed		640
Sec. 36, T. 31 N., R. 16 E., M. D.	Surveyed		320
Sec. 16, T. 32 N., R. 16 E., M. D.	Surveyed		520
Sec. 36, T. 32 N., R. 16 E., M. D.	Surveyed		640
Sec. 16, T. 34 N., R. 16 E., M. D.	Surveyed		640
Sec. 36, T. 34 N., R. 16 E., M. D.	Surveyed		560
Sec. 16, T. 36 N., R. 16 E., M. D.	Surveyed		640
Sec. 36, T. 36 N., R. 16 E., M. D.	Surveyed		240
Sec. 16, T. 37 N., R. 16 E., M. D.	Surveyed		240
Sec. 36, T. 37 N., R. 16 E., M. D.	Surveyed		400
Sec. 36, T. 38 N., R. 16 E., M. D.	Surveyed		640
Sec. 16, T. 39 N., R. 16 E., M. D.	Surveyed	80	
Sec. 36, T. 39 N., R. 16 E., M. D.	Surveyed		160
Sec. 16, T. 40 N., R. 16 E., M. D.	Surveyed	640	
Sec. 16, T. 41 N., R. 16 E., M. D.	Surveyed		160
Sec. 36, T. 47 N., R. 16 E., M. D.	Surveyed		40
Sec. 16, T. 48 N., R. 16 E., M. D.	Unsurveyed		640
Sec. 36, T. 48 N., R. 16 E., M. D.	Unsurveyed		640
Sec. 36, T. 1 N., R. 17 E., M. D.	Surveyed	240	
Sec. 36, T. 2 N., R. 17 E., M. D.	Surveyed	320	
Sec. 16, T. 7 N., R. 17 E., M. D.	Surveyed	40	
Sec. 16, T. 16 N., R. 17 E., M. D.	Surveyed	640	
Sec. 16, T. 20 N., R. 17 E., M. D.	Surveyed		400
Sec. 16, T. 21 N., R. 17 E., M. D.	Surveyed		560
Sec. 16, T. 22 N., R. 17 E., M. D.	Surveyed		480
Sec. 36, T. 22 N., R. 17 E., M. D.	Surveyed		701.64
Sec. 36, T. 23 N., R. 17 E., M. D.	Surveyed		597.04
Sec. 16, T. 24 N., R. 17 E., M. D.	Surveyed	320	
Sec. 16, T. 25 N., R. 17 E., M. D.	Surveyed		80
Sec. 16, T. 26 N., R. 17 E., M. D.	Surveyed		40
Sec. 16, T. 28 N., R. 17 E., M. D.	Surveyed		640
Sec. 36, T. 28 N., R. 17 E., M. D.	Surveyed		240
Sec. 16, T. 29 N., R. 17 E., M. D.	Surveyed		640
Sec. 36, T. 29 N., R. 17 E., M. D.	Surveyed		719.80
Sec. 16, T. 30 N., R. 17 E., M. D.	Surveyed		640
Sec. 36, T. 30 N., R. 17 E., M. D.	Surveyed		822.28
Sec. 16, T. 31 N., R. 17 E., M. D.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 32 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 33 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 34 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 37 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 40 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 41 N., R. 17 E., M. D.	Surveyed		160	160
Sec. 16, T. 42 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 43 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 44 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 45 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 46 N., R. 17 E., M. D.	Surveyed		640	640
Sec. 16, T. 47 N., R. 17 E., M. D.	Surveyed		38.49	38.49
Sec. 36, T. 1 N., R. 18 E., M. D.	Surveyed	600		600
Sec. 16, T. 5 N., R. 18 E., M. D.	Unsurveyed	5.29		5.29
Sec. 36, T. 7 N., R. 18 E., M. D.	Surveyed	39.42		39.42
Sec. 36, T. 12 N., R. 18 E., M. D.	Surveyed	306.35		306.35
Sec. 36, T. 24 N., R. 18 E., M. D.	Surveyed		320	320
Sec. 36, T. 5 N., R. 19 E., M. D.	Unsurveyed	40		40
Sec. 36, T. 7 N., R. 19 E., M. D.	Surveyed	5.72		5.72
Sec. 36, T. 9 N., R. 19 E., M. D.	Surveyed	42.45		42.45
Sec. 16, T. 11 N., R. 19 E., M. D.	Surveyed	320		320
Sec. 36, T. 2 N., R. 20 E., M. D.	Surveyed	40		40
Sec. 16, T. 4 N., R. 20 E., M. D.	Unsurveyed	360		360
Sec. 36, T. 4 N., R. 20 E., M. D.	Unsurveyed	40.01		40.01
Sec. 36, T. 6 N., R. 20 E., M. D.	Surveyed	12		12
Sec. 36, T. 7 N., R. 20 E., M. D.	Surveyed	.77		.77
Sec. 36, T. 8 N., R. 20 E., M. D.	Surveyed	213.89		213.89
Sec. 36, T. 10 N., R. 20 E., M. D.	Surveyed	41.15		41.15
Sec. 16, T. 11 N., R. 20 E., M. D.	Surveyed		351.74	351.74
Sec. 36, T. 11 N., R. 20 E., M. D.	Surveyed	513.12		513.12
Sec. 36, T. 1 N., R. 21 E., M. D.	Surveyed	1.60		1.60
Sec. 36, T. 2 N., R. 21 E., M. D.	Surveyed	9.49		9.49
Sec. 16, T. 3 N., R. 21 E., M. D.	Unsurveyed	360		360
Sec. 36, T. 6 N., R. 21 E., M. D.	Unsurveyed	14.30		14.30
Sec. 16, T. 11 N., R. 21 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 11 N., R. 21 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 1 N., R. 22 E., M. D.	Surveyed		1.14	1.14
Sec. 36, T. 2 N., R. 22 E., M. D.	Surveyed	41.64		41.64
Sec. 16, T. 7 N., R. 22 E., M. D.	Surveyed	320		320
Sec. 36, T. 8 N., R. 22 E., M. D.	Surveyed		80	80
Sec. 16, T. 9 N., R. 22 E., M. D.	Surveyed		400	400
Sec. 36, T. 2 N., R. 23 E., M. D.	Surveyed	1.94		1.94
Sec. 16, T. 5 N., R. 23 E., M. D.	Surveyed	30		30
Sec. 16, T. 7 N., R. 23 E., M. D.	Surveyed	29.58		29.58
Sec. 36, T. 7 N., R. 23 E., M. D.	Surveyed	370.42		370.42
Sec. 36, T. 8 N., R. 23 E., M. D.	Surveyed	640		640
Sec. 36, T. 1 N., R. 24 E., M. D.	Surveyed	1.09		1.09
Sec. 16, T. 4 N., R. 24 E., M. D.	Surveyed	160		160
Sec. 36, T. 4 N., R. 24 E., M. D.	Surveyed		160	160
Sec. 16, T. 7 N., R. 24 E., M. D.	Surveyed	640		640
Sec. 36, T. 8 N., R. 24 E., M. D.	Unsurveyed	200		200
Sec. 36, T. 7 N., R. 24 E., M. D.	Surveyed	640		640
Sec. 16, T. 8 N., R. 24 E., M. D.	Unsurveyed	212.58		212.58
Sec. 36, T. 1 N., R. 25 E., M. D.	Surveyed	320		320
Sec. 16, T. 3 N., R. 25 E., M. D.	Surveyed		600	600
Sec. 36, T. 3 N., R. 25 E., M. D.	Surveyed		80	80
Sec. 16, T. 4 N., R. 25 E., M. D.	Surveyed		240	240
Sec. 36, T. 4 N., R. 25 E., M. D.	Surveyed	640		640
Sec. 36, T. 5 N., R. 25 E., M. D.	Surveyed		640	640
Sec. 36, T. 6 N., R. 25 E., M. D.	Surveyed	640		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 191
Sec. 16, T. 1 N., R. 26 E., M. D.	Surveyed		320	320
Sec. 16, T. 3 N., R. 26 E., M. D.	Surveyed		480	480
Sec. 16, T. 4 N., R. 26 E., M. D.	Surveyed		640	640
Sec. 36, T. 4 N., R. 26 E., M. D.	Surveyed		640	640
Sec. 16, T. 5 N., R. 26 E., M. D.	Surveyed		640	640
Sec. 36, T. 5 N., R. 26 E., M. D.	Surveyed		480	480
Sec. 16, T. 6 N., R. 26 E., M. D.	Surveyed	640		640
Sec. 36, T. 6 N., R. 26 E., M. D.	Surveyed		600	600
Sec. 16, T. 3 N., R. 27 E., M. D.	Surveyed		320	320
Sec. 36, T. 4 N., R. 27 E., M. D.	Surveyed		640	640
Sec. 16, T. 5 N., R. 27 E., M. D.	Surveyed		640	640
Sec. 36, T. 5 N., R. 27 E., M. D.	Surveyed		440	440
Sec. 36, T. 1 N., R. 28 E., M. D.	Surveyed	640		640
Sec. 36, T. 2 N., R. 28 E., M. D.	Surveyed		640	640
Sec. 16, T. 3 N., R. 28 E., M. D.	Surveyed		480	480
Sec. 36, T. 3 N., R. 28 E., M. D.	Surveyed		160	160
Sec. 16, T. 4 N., R. 28 E., M. D.	Surveyed		640	640
Sec. 36, T. 4 N., R. 28 E., M. D.	Surveyed		640	640
Sec. 16, T. 1 N., R. 29 E., M. D.	Unsurveyed		23.49	23
Sec. 36, T. 1 N., R. 29 E., M. D.	Unsurveyed		160	160
Sec. 16, T. 2 N., R. 29 E., M. D.	Surveyed	640		640
Sec. 36, T. 2 N., R. 29 E., M. D.	Surveyed	640		640
Sec. 16, T. 3 N., R. 29 E., M. D.	Surveyed	640		640
Sec. 36, T. 3 N., R. 29 E., M. D.	Surveyed	320		320
Sec. 36, T. 1 N., R. 30 E., M. D.	Surveyed		640	640
Sec. 16, T. 2 N., R. 30 E., M. D.	Surveyed	480		480
Sec. 36, T. 2 N., R. 30 E., M. D.	Surveyed	640		640
Sec. 16, T. 1 N., R. 31 E., M. D.	Surveyed	200		200
Sec. 36, T. 1 N., R. 31 E., M. D.	Surveyed	640		640
Sec. 16, T. 2 N., R. 1 W., M. D.	Surveyed		10	10
Sec. 16, T. 3 N., R. 1 W., M. D.	Surveyed		600	600
Sec. 16, T. 4 N., R. 1 W., M. D.	Surveyed		66.02	66
Sec. 16, T. 14 N., R. 1 W., M. D.	Surveyed		640	640
Sec. 16, T. 15 N., R. 1 W., M. D.	Surveyed		240	240
Sec. 36, T. 17 N., R. 1 W., M. D.	Surveyed		40	40
Sec. 36, T. 18 N., R. 1 W., M. D.	Surveyed		320	320
Sec. 16, T. 22 N., R. 1 W., M. D.	Surveyed		480	480
Sec. 16, T. 23 N., R. 1 W., M. D.	Surveyed		.18	
Sec. 36, T. 23 N., R. 1 W., M. D.	Surveyed		480	480
Sec. 36, T. 27 N., R. 1 W., M. D.	Surveyed		80	80
Sec. 36, T. 34 N., R. 1 W., M. D.	Surveyed		40	40
Sec. 16, T. 35 N., R. 1 W., M. D.	Surveyed		466.92	466
Sec. 16, T. 36 N., R. 1 W., M. D.	Surveyed		80	80
Sec. 16, T. 38 N., R. 1 W., M. D.	Surveyed	640		640
Sec. 36, T. 42 N., R. 1 W., M. D.	Surveyed		240	240
Sec. 16, T. 43 N., R. 1 W., M. D.	Surveyed		160	160
Sec. 36, T. 43 N., R. 1 W., M. D.	Surveyed	160		160
Sec. 16, T. 44 N., R. 1 W., M. D.	Surveyed		160	160
Sec. 16, T. 45 N., R. 1 W., M. D.	Surveyed		160	160
Sec. 36, T. 45 N., R. 1 W., M. D.	Surveyed		360	360
Sec. 36, T. 5 N., R. 2 W., M. D.	Surveyed		320	320
Sec. 16, T. 6 N., R. 2 W., M. D.	Surveyed		120	120
Sec. 16, T. 7 N., R. 2 W., M. D.	Surveyed		120	120
Sec. 16, T. 24 N., R. 2 W., M. D.	Surveyed		137.50	137
Sec. 16, T. 29 N., R. 2 W., M. D.	Surveyed		320	320
Sec. 16, T. 32 N., R. 2 W., M. D.	Surveyed		440	440
Sec. 16, T. 33 N., R. 2 W., M. D.	Surveyed		146.21	146
Sec. 16, T. 34 N., R. 2 W., M. D.	Surveyed	80		80
Sec. 36, T. 35 N., R. 2 W., M. D.	Surveyed	170.80		170
Sec. 36, T. 36 N., R. 2 W., M. D.	Surveyed	80		80

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 37 N., R. 2 W., M. D.	Surveyed	81.10		81.10
Sec 36, T. 38 N., R. 2 W., M. D.	Surveyed	40		40
Sec. 16, T. 42 N., R. 2 W., M. D.	Surveyed	80		80
Sec. 36, T. 42 N., R. 2 W., M. D.	Surveyed	80.85		80.85
Sec. 36, T. 8 N., R. 3 W., M. D.	Surveyed		200	200
Sec. 16, T. 19 N., R. 3 W., M. D.	Surveyed		480	480
Sec. 16, T. 33 N., R. 3 W., M. D.	Surveyed		640	640
Sec. 36, T. 34 N., R. 3 W., M. D.	Surveyed		600	600
Sec. 36, T. 35 N., R. 3 W., M. D.	Surveyed	560		560
Sec. 16, T. 37 N., R. 3 W., M. D.	Surveyed	80		80
Sec. 36, T. 37 N., R. 3 W., M. D.	Surveyed	200		200
Sec. 36, T. 41 N., R. 3 W., M. D.	Surveyed	320		320
Sec. 16, T. 42 N., R. 3 W., M. D.	Surveyed	160		160
Sec. 16, T. 45 N., R. 3 W., M. D.	Surveyed		360	360
Sec. 16, T. 46 N., R. 3 W., M. D.	Surveyed	223.88		223.88
Sec. 36, T. 46 N., R. 3 W., M. D.	Surveyed		40	40
Sec. 36, T. 48 N., R. 3 W., M. D.	Surveyed		320	320
Sec. 16, T. 3 N., R. 4 W., M. D.	Surveyed		.76	.76
Sec. 16, T. 9 N., R. 4 W., M. D.	Surveyed		560	560
Sec. 36, T. 10 N., R. 4 W., M. D.	Surveyed		10.39	10.39
Sec. 16, T. 11 N., R. 4 W., M. D.	Surveyed		80	80
Sec. 36, T. 12 N., R. 4 W., M. D.	Surveyed		400	400
Sec. 16, T. 29 N., R. 4 W., M. D.	Surveyed		160	160
Sec. 16, T. 33 N., R. 4 W., M. D.	Surveyed		120	120
Sec. 16, T. 34 N., R. 4 W., M. D.	Surveyed		640	640
Sec. 16, T. 35 N., R. 4 W., M. D.	Surveyed		640	640
Sec. 36, T. 35 N., R. 4 W., M. D.	Surveyed		320	320
Sec. 16, T. 36 N., R. 4 W., M. D.	Surveyed		120	120
Sec. 36, T. 30 N., R. 4 W., M. D.	Surveyed		560	560
Sec. 36, T. 38 N., R. 4 W., M. D.	Surveyed	640		640
Sec. 36, T. 41 N., R. 4 W., M. D.	Surveyed	320		320
Sec. 36, T. 42 N., R. 4 W., M. D.	Surveyed	120		120
Sec. 36, T. 43 N., R. 4 W., M. D.	Surveyed	160		160
Sec. 16, T. 44 N., R. 4 W., M. D.	Surveyed		80	80
Sec. 36, T. 45 N., R. 4 W., M. D.	Surveyed		640	640
Sec. 36, T. 46 N., R. 4 W., M. D.	Surveyed		80	80
Sec. 36, T. 4 N., R. 5 W., M. D.	Surveyed		5.34	5.34
Sec. 16, T. 11 N., R. 5 W., M. D.	Surveyed		480	480
Sec. 36, T. 11 N., R. 5 W., M. D.	Surveyed		80.98	80.98
Sec. 16, T. 12 N., R. 5 W., M. D.	Surveyed		160	160
Sec. 16, T. 13 N., R. 5 W., M. D.	Surveyed		240	240
Sec. 36, T. 13 N., R. 5 W., M. D.	Surveyed		160	160
Sec. 16, T. 29 N., R. 5 W., M. D.	Surveyed		320	320
Sec. 36, T. 33 N., R. 5 W., M. D.	Surveyed		440	440
Sec. 36, T. 35 N., R. 5 W., M. D.	Surveyed		320	320
Sec. 16, T. 36 N., R. 5 W., M. D.	Surveyed		240	240
Sec. 36, T. 36 N., R. 5 W., M. D.	Surveyed		320	320
Sec. 36, T. 37 N., R. 5 W., M. D.	Surveyed		80	80
Sec. 36, T. 39 N., R. 5 W., M. D.	Surveyed	80		80
Sec. 16, T. 47 N., R. 5 W., M. D.	Surveyed		600	600
Sec. 16, T. 48 N., R. 5 W., M. D.	Surveyed		.10	.10
Sec. 16, T. 9 N., R. 6 W., M. D.	Surveyed		480	480
Sec. 36, T. 11 N., R. 6 W., M. D.	Surveyed		640	640
Sec. 16, T. 16 N., R. 6 W., M. D.	Surveyed		480	480
Sec. 36, T. 19 N., R. 6 W., M. D.	Surveyed		125.67	125.67
Sec. 16, T. 32 N., R. 6 W., M. D.	Surveyed		160	160
Sec. 36, T. 32 N., R. 6 W., M. D.	Surveyed		31.68	31.68
Sec. 16, T. 33 N., R. 6 W., M. D.	Surveyed		520	520
Sec. 16, T. 35 N., R. 6 W., M. D.	Surveyed	40		40
Sec. 36, T. 35 N., R. 6 W., M. D.	Surveyed		320	320

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 37 N., R. 6 W., M. D.	Surveyed	200	
Sec. 16, T. 39 N., R. 6 W., M. D.	Surveyed	81.70	
Sec. 36, T. 39 N., R. 6 W., M. D.	Surveyed	80	
Sec. 16, T. 40 N., R. 6 W., M. D.	Surveyed	120	
Sec. 36, T. 40 N., R. 6 W., M. D.	Surveyed	19.80	
Sec. 16, T. 41 N., R. 6 W., M. D.	Surveyed	320	
Sec. 36, T. 41 N., R. 6 W., M. D.	Surveyed	160	
Sec. 16, T. 44 N., R. 6 W., M. D.	Surveyed		320
Sec. 16, T. 48 N., R. 6 W., M. D.	Surveyed	227.68	
Sec. 16, T. 14 N., R. 7 W., M. D.	Surveyed		320
Sec. 16, T. 15 N., R. 7 W., M. D.	Surveyed		640
Sec. 36, T. 15 N., R. 7 W., M. D.	Surveyed		640
Sec. 36, T. 16 N., R. 7 W., M. D.	Surveyed	146.52	
Sec. 36, T. 17 N., R. 7 W., M. D.	Surveyed	640	
Sec. 36, T. 19 N., R. 7 W., M. D.	Surveyed	240	
Sec. 16, T. 22 N., R. 7 W., M. D.	Surveyed	520	
Sec. 16, T. 24 N., R. 7 W., M. D.	Surveyed		640
Sec. 16, T. 25 N., R. 7 W., M. D.	Surveyed		640
Sec. 36, T. 25 N., R. 7 W., M. D.	Surveyed		240
Sec. 36, T. 26 N., R. 7 W., M. D.	Surveyed		120
Sec. 36, T. 33 N., R. 7 W., M. D.	Surveyed		160
Sec. 36, T. 34 N., R. 7 W., M. D.	Surveyed		480
Sec. 16, T. 35 N., R. 7 W., M. D.	Surveyed	160	
Sec. 36, T. 35 N., R. 7 W., M. D.	Surveyed		640
Sec. 36, T. 36 N., R. 7 W., M. D.	Surveyed	480	
Sec. 36, T. 38 N., R. 7 W., M. D.	Surveyed	120	
Sec. 16, T. 39 N., R. 7 W., M. D.	Surveyed	160	
Sec. 36, T. 39 N., R. 7 W., M. D.	Surveyed	120	
Sec. 16, T. 40 N., R. 7 W., M. D.	Surveyed	80	
Sec. 16, T. 41 N., R. 7 W., M. D.	Surveyed		320
Sec. 36, T. 41 N., R. 7 W., M. D.	Surveyed	260	
Sec. 16, T. 42 N., R. 7 W., M. D.	Surveyed		240
Sec. 16, T. 43 N., R. 7 W., M. D.	Surveyed		200
Sec. 16, T. 44 N., R. 7 W., M. D.	Surveyed		80
Sec. 36, T. 44 N., R. 7 W., M. D.	Surveyed		120
Sec. 16, T. 45 N., R. 7 W., M. D.	Surveyed		611.68
Sec. 36, T. 46 N., R. 7 W., M. D.	Surveyed		240
Sec. 36, T. 47 N., R. 7 W., M. D.	Surveyed	400	
Sec. 16, T. 1 N., R. 8 W., M. D.	Unsurveyed		40
Sec. 16, T. 11 N., R. 8 W., M. D.	Surveyed		160
Sec. 16, T. 12 N., R. 8 W., M. D.	Surveyed		160
Sec. 36, T. 12 N., R. 8 W., M. D.	Surveyed		80
Sec. 16, T. 15 N., R. 8 W., M. D.	Surveyed	575.14	
Sec. 36, T. 15 N., R. 8 W., M. D.	Surveyed		163.73
Sec. 16, T. 16 N., R. 8 W., M. D.	Surveyed	360	
Sec. 36, T. 16 N., R. 8 W., M. D.	Surveyed		440
Sec. 36, T. 17 N., R. 8 W., M. D.	Surveyed	245.81	
Sec. 16, T. 18 N., R. 8 W., M. D.	Surveyed	440	
Sec. 16, T. 19 N., R. 8 W., M. D.	Surveyed	480	
Sec. 16, T. 22 N., R. 8 W., M. D.	Surveyed	320	
Sec. 16, T. 27 N., R. 8 W., M. D.	Surveyed		640
Sec. 36, T. 27 N., R. 8 W., M. D.	Surveyed		640
Sec. 36, T. 28 N., R. 8 W., M. D.	Surveyed		320
Sec. 16, T. 29 N., R. 8 W., M. D.	Surveyed		160
Sec. 36, T. 29 N., R. 8 W., M. D.	Surveyed		48.17
Sec. 16, T. 30 N., R. 8 W., M. D.	Surveyed		640
Sec. 36, T. 33 N., R. 8 W., M. D.	Surveyed		80
Sec. 16, T. 34 N., R. 8 W., M. D.	Surveyed	58.66	
Sec. 36, T. 34 N., R. 8 W., M. D.	Surveyed		480
Sec. 36, T. 35 N., R. 8 W., M. D.	Surveyed	.21	

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 37 N., R. 8 W., M. D.	Surveyed	640		640
Sec. 36, T. 37 N., R. 8 W., M. D.	Surveyed	229.69		229.69
Sec. 16, T. 38 N., R. 8 W., M. D.	Surveyed	105.61		105.61
Sec. 36, T. 39 N., R. 8 W., M. D.	Surveyed	161.50		161.50
Sec. 36, T. 40 N., R. 8 W., M. D.	Surveyed	160		160
Sec. 36, T. 41 N., R. 8 W., M. D.	Surveyed		160	160
Sec. 36, T. 42 N., R. 8 W., M. D.	Surveyed		640	640
Sec. 16, T. 45 N., R. 8 W., M. D.	Surveyed	240		240
Sec. 36, T. 47 N., R. 8 W., M. D.	Surveyed	520		520
Sec. 16, T. 6 N., R. 9 W., M. D.	Surveyed		480	480
Sec. 16, T. 12 N., R. 9 W., M. D.	Surveyed		640	640
Sec. 16, T. 16 N., R. 9 W., M. D.	Surveyed	1.05		1.05
Sec. 36, T. 16 N., R. 9 W., M. D.	Surveyed	40		40
Sec. 36, T. 17 N., R. 9 W., M. D.	Surveyed	74.39		74.39
Sec. 16, T. 19 N., R. 9 W., M. D.	Surveyed	480		480
Sec. 36, T. 21 N., R. 9 W., M. D.	Surveyed	440		440
Sec. 16, T. 25 N., R. 9 W., M. D.	Surveyed	640		640
Sec. 36, T. 26 N., R. 9 W., M. D.	Surveyed	560		560
Sec. 36, T. 28 N., R. 9 W., M. D.	Surveyed		480	480
Sec. 16, T. 29 N., R. 9 W., M. D.	Surveyed		280	280
Sec. 36, T. 29 N., R. 9 W., M. D.	Surveyed		320	320
Sec. 16, T. 30 N., R. 9 W., M. D.	Surveyed		200	200
Sec. 16, T. 32 N., R. 9 W., M. D.	Surveyed		640	640
Sec. 36, T. 32 N., R. 9 W., M. D.	Surveyed		640	640
Sec. 36, T. 33 N., R. 9 W., M. D.	Surveyed		120	120
Sec. 16, T. 34 N., R. 9 W., M. D.	Surveyed	80		80
Sec. 36, T. 34 N., R. 9 W., M. D.	Surveyed		160	160
Sec. 16, T. 36 N., R. 9 W., M. D.	Surveyed	120.54		120.54
Sec. 36, T. 36 N., R. 9 W., M. D.	Surveyed	240		240
Sec. 36, T. 37 N., R. 9 W., M. D.	Surveyed	261.38		261.38
Sec. 16, T. 38 N., R. 9 W., M. D.	Surveyed	80		80
Sec. 36, T. 38 N., R. 9 W., M. D.	Surveyed	216.38		216.38
Sec. 36, T. 39 N., R. 9 W., M. D.	Surveyed	80		80
Sec. 16, T. 40 N., R. 9 W., M. D.	Surveyed	480		480
Sec. 36, T. 40 N., R. 9 W., M. D.	Surveyed	203.72		203.72
Sec. 16, T. 42 N., R. 9 W., M. D.	Surveyed		80	80
Sec. 16, T. 46 N., R. 9 W., M. D.	Surveyed	2.64		2.64
Sec. 36, T. 46 N., R. 9 W., M. D.	Surveyed	640		640
Sec. 36, T. 48 N., R. 9 W., M. D.	Surveyed	320		320
Sec. 16, T. 7 N., R. 10 W., M. D.	Surveyed		147.22	147.22
Sec. 16, T. 12 N., R. 10 W., M. D.	Surveyed		160	160
Sec. 16, T. 13 N., R. 10 W., M. D.	Surveyed		320	320
Sec. 16, T. 15 N., R. 10 W., M. D.	Surveyed		40	40
Sec. 36, T. 17 N., R. 10 W., M. D.	Surveyed	80		80
Sec. 36, T. 19 N., R. 10 W., M. D.	Surveyed	600		600
Sec. 36, T. 21 N., R. 10 W., M. D.	Surveyed	200		200
Sec. 16, T. 22 N., R. 10 W., M. D.	Surveyed	440		440
Sec. 16, T. 23 N., R. 10 W., M. D.	Surveyed	360		360
Sec. 36, T. 23 N., R. 10 W., M. D.	Surveyed	480		480
Sec. 36, T. 24 N., R. 10 W., M. D.	Surveyed	320		320
Sec. 36, T. 29 N., R. 10 W., M. D.	Surveyed	.16		.16
Sec. 36, T. 31 N., R. 10 W., M. D.	Surveyed	80		80
Sec. 36, T. 32 N., R. 10 W., M. D.	Surveyed		40	40
Sec. 36, T. 36 N., R. 10 W., M. D.	Surveyed	80		80
Sec. 16, T. 37 N., R. 10 W., M. D.	Surveyed	82.18		82.18
Sec. 36, T. 37 N., R. 10 W., M. D.	Surveyed	163.01		163.01
Sec. 16, T. 38 N., R. 10 W., M. D.	Surveyed	160		160
Sec. 16, T. 39 N., R. 10 W., M. D.	Surveyed	80		80
Sec. 36, T. 39 N., R. 10 W., M. D.	Surveyed	60		60
Sec. 16, T. 40 N., R. 10 W., M. D.	Surveyed	130.70		130.70

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 36, T. 40 N., R. 10 W., M. D.	Surveyed	280	
Sec 16, T. 41 N., R. 10 W., M. D.	Surveyed	240	
Sec. 36, T. 41 N., R. 10 W., M. D.	Surveyed		40
Sec. 36, T. 48 N., R. 10 W., M. D.	Surveyed	239.65	
Sec. 16, T. 5 N., R. 11 W., M. D.	Unsurveyed		640
Sec. 36, T. 5 N., R. 11 W., M. D.	Unsurveyed		640
Sec. 36, T. 8 N., R. 11 W., M. D.	Surveyed	29.80	
Sec. 16, T. 9 N., R. 11 W., M. D.	Surveyed		80
Sec. 36, T. 14 N., R. 11 W., M. D.	Surveyed		660.48
Sec. 16, T. 15 N., R. 11 W., M. D.	Surveyed		568.72
Sec. 16, T. 18 N., R. 11 W., M. D.	Surveyed		320
Sec. 36, T. 18 N., R. 11 W., M. D.	Surveyed	600	
Sec. 16, T. 20 N., R. 11 W., M. D.	Surveyed		640
Sec. 16, T. 21 N., R. 11 W., M. D.	Surveyed		640
Sec. 16, T. 23 N., R. 11 W., M. D.	Surveyed		480
Sec 36, T. 24 N., R. 11 W., M. D.	Surveyed	480	
Sec. 36, T. 25 N., R. 11 W., M. D.	Surveyed	160	
Sec. 16, T. 26 N., R. 11 W., M. D.	Surveyed	640	
Sec 36, T. 27 N., R. 11 W., M. D.	Surveyed	160	
Sec. 36, T. 32 N., R. 11 W., M. D.	Surveyed	200	
Sec. 16, T. 35 N., R. 11 W., M. D.	Surveyed	109.21	
Sec. 16, T. 36 N., R. 11 W., M. D.	Surveyed	80	
Sec. 36, T. 36 N., R. 11 W., M. D.	Surveyed	20	
Sec. 16, T. 37 N., R. 11 W., M. D.	Surveyed	80	
Sec. 16, T. 38 N., R. 11 W., M. D.	Surveyed	40	
Sec. 36, T. 38 N., R. 11 W., M. D.	Surveyed	160	
Sec 16, T. 39 N., R. 11 W., M. D.	Surveyed	200	
Sec. 36, T. 39 N., R. 11 W., M. D.	Surveyed	213.56	
Sec. 36, T. 40 N., R. 11 W., M. D.	Surveyed	320	
Sec. 16, T. 41 N., R. 11 W., M. D.	Surveyed	582.48	
Sec. 36, T. 41 N., R. 11 W., M. D.	Surveyed	160	
Sec. 36, T. 42 N., R. 11 W., M. D.	Surveyed	20	
Sec 16, T. 44 N., R. 11 W., M. D.	Surveyed	280	
Sec. 16, T 45 N., R. 11 W., M. D.	Surveyed	240	
Sec. 36, T. 46 N., R. 11 W., M. D.	Surveyed	11.62	
Sec. 36, T. 47 N., R. 11 W., M. D.	Surveyed	80	
Sec. 16, T. 48 N., R. 11 W., M. D.	Surveyed		109.20
Sec. 36, T. 48 N., R. 11 W., M. D.	Surveyed	189.20	
Sec. 16, T. 17 N., R. 12 W., M. D.	Surveyed		80
Sec. 36, T. 17 N., R. 12 W., M. D.	Surveyed		520
Sec. 16, T. 18 N., R. 12 W., M. D.	Surveyed		600
Sec. 36, T. 18 N., R. 12 W., M. D.	Surveyed		40
Sec. 36, T. 19 N., R. 12 W., M. D.	Surveyed		40
Sec. 36, T. 21 N., R. 12 W., M. D.	Surveyed		80
Sec. 16, T. 25 N., R. 12 W., M. D.	Surveyed		640
Sec. 36, T. 25 N., R. 12 W., M. D.	Surveyed	560	
Sec. 16, T. 27 N., R. 12 W., M. D.	Surveyed	120	
Sec. 16, T. 28 N., R. 12 W., M. D.	Surveyed	40	
Sec. 36, T. 29 N., R. 12 W., M. D.	Surveyed	25.95	
Sec. 16, T. 30 N., R. 12 W., M. D.	Surveyed	120	
Sec. 36, T. 30 N., R. 12 W., M. D.	Surveyed	120	
Sec. 36, T. 31 N., R. 12 W., M. D.	Surveyed	80	
Sec. 16, T. 32 N., R. 12 W., M. D.	Surveyed	160	
Sec. 36, T. 32 N., R. 12 W., M. D.	Surveyed	240	
Sec 16, T. 34 N., R. 12 W., M. D.	Surveyed	200	
Sec. 36, T. 36 N., R. 12 W., M. D.	Surveyed	600	
Sec. 16, T. 37 N., R. 12 W., M. D.	Unsurveyed	600	
Sec. 36, T. 37 N., R. 12 W., M. D.	Unsurveyed	149.13	
Sec. 36, T. 39 N., R. 12 W., M. D.	Surveyed	40	
Sec. 16, T. 40 N., R. 12 W., M. D.	Surveyed	80	

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 40 N., R. 12 W., M. D.	Surveyed	210.12		210.12
Sec. 16, T. 41 N., R. 12 W., M. D.	Surveyed	25.07		25.07
Sec. 36, T. 42 N., R. 12 W., M. D.	Surveyed	39.36		39.36
Sec. 16, T. 44 N., R. 12 W., M. D.	Surveyed	39.02		39.02
Sec. 36, T. 44 N., R. 12 W., M. D.	Surveyed	160		160
Sec. 16, T. 45 N., R. 12 W., M. D.	Surveyed	600		600
Sec. 36, T. 45 N., R. 12 W., M. D.	Surveyed	600		600
Sec. 36, T. 46 N., R. 12 W., M. D.	Surveyed	200		200
Sec. 36, T. 48 N., R. 12 W., M. D.	Surveyed	280		280
Sec. 36, T. 8 N., R. 13 W., M. D.	Surveyed		160	160
Sec. 36, T. 12 N., R. 13 W., M. D.	Surveyed		160	160
Sec. 16, T. 14 N., R. 13 W., M. D.	Surveyed		320	320
Sec. 36, T. 14 N., R. 13 W., M. D.	Surveyed		640	640
Sec. 16, T. 15 N., R. 13 W., M. D.	Surveyed		80	80
Sec. 36, T. 15 N., R. 13 W., M. D.	Surveyed		440	440
Sec. 36, T. 18 N., R. 13 W., M. D.	Surveyed		40.02	40.02
Sec. 16, T. 19 N., R. 13 W., M. D.	Surveyed		80	80
Sec. 36, T. 20 N., R. 13 W., M. D.	Surveyed		480	480
Sec. 16, T. 21 N., R. 13 W., M. D.	Surveyed		240	240
Sec. 16, T. 23 N., R. 13 W., M. D.	Surveyed		.29	.29
Sec. 36, T. 24 N., R. 13 W., M. D.	Surveyed		.63	.63
Sec 16, T. 12 N., R. 14 W., M. D.	Surveyed		2.68	2.68
Sec. 16, T. 21 N., R. 14 W., M. D.	Surveyed		120	120
Sec. 16, T. 17 N., R. 16 W., M. D.	Surveyed		320	320
Sec. 36, T. 22 N., R. 16 W., M. D.	Surveyed		640	640
Sec. 36, T. 23 N., R. 16 W., M. D.	Surveyed		640	640
Sec. 36, T. 24 N., R. 16 W., M. D.	Surveyed		640	640
Sec. 36, T. 17 N., R. 17 W., M. D.	Surveyed		480	480
Sec. 16, T. 20 N., R. 17 W., M. D.	Surveyed		640	640
Sec. 16, T. 21 N., R. 17 W., M. D.	Surveyed		.10	.10
Sec. 16, T. 23 N., R. 17 W., M. D.	Surveyed		2.23	2.23
Sec. 36, T. 2 S., R. 1 W., M. D.	Surveyed		.92	.92
Sec. 16, T. 9 S., R. 1 W., M. D.	Surveyed		2.18	2.18
Sec. 16, T. 10 S., R. 1 W., M. D.	Surveyed		280	280
Sec. 36, T. 8 S., R. 2 W., M. D.	Surveyed		160	160
Sec. 36, T. 7 S., R. 5 W., M. D.	Surveyed		560	560
Sec. 36, T. 1 S., R. 1 E., M. D.	Surveyed		323.72	323.72
Sec. 16, T. 18 S., R. 2 E., M. D.	Surveyed	640		640
Sec. 16, T. 18 S., R. 3 E., M. D.	Surveyed		320	320
Sec. 36, T. 18 S., R. 3 E., M. D.	Surveyed	280		280
Sec. 36, T. 19 S., R. 3 E., M. D.	Surveyed	120		120
Sec. 16, T. 20 S., R. 3 E., M. D.	Surveyed	160		160
Sec. 36, T. 20 S., R. 3 E., M. D.	Surveyed	160		160
Sec. 36, T. 5 S., R. 4 E., M. D.	Surveyed		640	640
Sec. 36, T. 7 S., R. 4 E., M. D.	Surveyed		520	520
Sec. 16, T. 9 S., R. 4 E., M. D.	Surveyed		84.70	84.70
Sec. 36, T. 19 S., R. 4 E., M. D.	Surveyed	40		40
Sec. 16, T. 1 S., R. 5 E., M. D.	Surveyed		160	160
Sec. 16, T. 2 S., R. 5 E., M. D.	Surveyed		280	280
Sec. 16, T. 7 S., R. 5 E., M. D.	Surveyed		480	480
Sec. 36, T. 7 S., R. 5 E., M. D.	Surveyed		520	520
Sec. 16, T. 8 S., R. 5 E., M. D.	Surveyed		600	600
Sec. 16, T. 14 S., R. 5 E., M. D.	Surveyed		331.45	331.45
Sec. 36, T. 18 S., R. 5 E., M. D.	Surveyed		320	320
Sec. 16, T. 19 S., R. 5 E., M. D.	Surveyed		320	320
Sec. 36, T. 19 S., R. 5 E., M. D.	Surveyed		360	360
Sec. 16, T. 23 S., R. 5 E., M. D.	Surveyed		200	200
Sec. 36, T. 23 S., R. 5 E., M. D.	Surveyed	320		320
Sec. 16, T. 9 S., R. 6 E., M. D.	Surveyed		640	640
Sec. 16, T. 11 S., R. 6 E., M. D.	Surveyed		106	106

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1913.
Sec. 36, T. 15 S., R. 6 E., M. D.	Surveyed		59.90	59.9
Sec. 16, T. 19 S., R. 6 E., M. D.	Surveyed		303.25	303.2
Sec. 16, T. 20 S., R. 6 E., M. D.	Surveyed	40		40
Sec. 16, T. 23 S., R. 6 E., M. D.	Surveyed	160		160
Sec. 36, T. 24 S., R. 6 E., M. D.	Surveyed		160	160
Sec. 16, T. 1 S., R. 7 E., M. D.	Surveyed		160	160
Sec. 36, T. 11 S., R. 7 E., M. D.	Surveyed		240	240
Sec. 36, T. 16 S., R. 7 E., M. D.	Surveyed		80	80
Sec. 36, T. 20 S., R. 7 E., M. D.	Surveyed		160	160
Sec. 16, T. 21 S., R. 7 E., M. D.	Surveyed		560	560
Sec. 36, T. 24 S., R. 7 E., M. D.	Surveyed		160	160
Sec. 16, T. 11 S., R. 8 E., M. D.	Surveyed		20.60	20.60
Sec. 16, T. 25 S., R. 8 E., M. D.	Surveyed		320	320
Sec. 36, T. 25 S., R. 8 E., M. D.	Surveyed		360	360
Sec. 36, T. 23 S., R. 9 E., M. D.	Surveyed		80	80
Sec. 16, T. 25 S., R. 9 E., M. D.	Surveyed		80	80
Sec. 36, T. 7 S., R. 10 E., M. D.	Surveyed		211.23	211.23
Sec. 36, T. 18 S., R. 10 E., M. D.	Surveyed		85.75	85.75
Sec. 16, T. 18 S., R. 11 E., M. D.	Surveyed	160		160
Sec. 36, T. 19 S., R. 11 E., M. D.	Surveyed	640		640
Sec. 36, T. 15 S., R. 12 E., M. D.	Surveyed		5.60	5.60
Sec. 36, T. 18 S., R. 12 E., M. D.	Surveyed	9.28		9.28
Sec. 16, T. 19 S., R. 12 E., M. D.	Surveyed	320		320
Sec. 36, T. 19 S., R. 12 E., M. D.	Surveyed	320		320
Sec. 16, T. 23 S., R. 12 E., M. D.	Surveyed	40		40
Sec. 16, T. 29 S., R. 12 E., M. D.	Surveyed	600		600
Sec. 36, T. 28 S., R. 13 E., M. D.	Surveyed		40.04	40.04
Sec. 16, T. 30 S., R. 13 E., M. D.	Surveyed	186.98		186.98
Sec. 36, T. 30 S., R. 13 E., M. D.	Surveyed		120	120
Sec. 36, T. 22 S., R. 14 E., M. D.	Surveyed		40	40
Sec. 36, T. 28 S., R. 14 E., M. D.	Surveyed		480	480
Sec. 36, T. 29 S., R. 14 E., M. D.	Surveyed		40	40
Sec. 16, T. 30 S., R. 14 E., M. D.	Surveyed		649.38	649.38
Sec. 36, T. 30 S., R. 14 E., M. D.	Surveyed		8.32	8.32
Sec. 16, T. 1 S., R. 15 E., M. D.	Surveyed		654.24	654.24
Sec. 16, T. 2 S., R. 15 E., M. D.	Surveyed		120	120
Sec. 36, T. 2 S., R. 15 E., M. D.	Surveyed		40	40
Sec. 36, T. 5 S., R. 15 E., M. D.	Surveyed		320	320
Sec. 16, T. 8 S., R. 15 E., M. D.	Surveyed		280	280
Sec. 36, T. 13 S., R. 15 E., M. D.	Surveyed		59.31	59.31
Sec. 16, T. 23 S., R. 15 E., M. D.	Surveyed		80	80
Sec. 16, T. 1 S., R. 16 E., M. D.	Surveyed		3.70	3.70
Sec. 16, T. 2 S., R. 16 E., M. D.	Surveyed		80	80
Sec. 36, T. 2 S., R. 16 E., M. D.	Surveyed		600	600
Sec. 36, T. 3 S., R. 16 E., M. D.	Surveyed		234.84	234.84
Sec. 16, T. 23 S., R. 16 E., M. D.	Surveyed		4.42	4.42
Sec. 16, T. 31 S., R. 16 E., M. D.	Surveyed	80		80
Sec. 36, T. 31 S., R. 16 E., M. D.	Surveyed	320		320
Sec. 36, T. 32 S., R. 16 E., M. D.	Surveyed	31.48		31.48
Sec. 36, T. 1. S., R. 17 E., M. D.	Surveyed	68.75		68.75
Sec. 16, T. 2 S., R. 17 E., M. D.	Surveyed	20		20
Sec. 36, T. 3 S., R. 17 E., M. D.	Surveyed		2.99	2.99
Sec. 36, T. 6 S., R. 17 E., M. D.	Surveyed		19.95	19.95
Sec. 16, T. 16 S., R. 17 E., M. D.	Surveyed		5.59	5.59
Sec. 36, T. 16 S., R. 17 E., M. D.	Surveyed		269.11	269.11
Sec. 36, T. 31 S., R. 17 E., M. D.	Surveyed	320		320
Sec. 16, T. 32 S., R. 17 E., M. D.	Surveyed	320		320
Sec. 16, T. 3 S., R. 18 E., M. D.	Surveyed	7.40		7.40
Sec. 36, T. 7 S., R. 18 E., M. D.	Surveyed		320	320
Sec. 16, T. 17 S., R. 18 E., M. D.	Surveyed		5.37	5.37

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 27 S., R. 18 E., M. D.	Surveyed		480	480
Sec. 16, T. 32 S., R. 18 E., M. D.	Surveyed	40		40
Sec. 36, T. 32 S., R. 18 E., M. D.	Surveyed		594.94	594.94
Sec. 36, T. 3 S., R. 19 E., M. D.	Surveyed		161.11	161.11
Sec. 36, T. 5 S., R. 19 E., M. D.	Surveyed		120.46	120.46
Sec. 16, T. 6 S., R. 19 E., M. D.	Surveyed		320	320
Sec. 16, T. 8 S., R. 19 E., M. D.	Surveyed		29.16	29.16
Sec. 36, T. 8 S., R. 19 E., M. D.	Surveyed		640	640
Sec. 36, T. 20 S., R. 19 E., M. D.	Surveyed		320	320
Sec. 16, T. 22 S., R. 19 E., M. D.	Surveyed		48.80	48.80
Sec. 36, T. 1 S., R. 20 E., M. D.	Surveyed	9.25		9.25
Sec. 16, T. 4 S., R. 20 E., M. D.	Surveyed	320		320
Sec. 16, T. 6 S., R. 20 E., M. D.	Surveyed		40.52	40.52
Sec. 36, T. 6 S., R. 20 E., M. D.	Surveyed		320	320
Sec. 36, T. 8 S., R. 20 E., M. D.	Surveyed		320	320
Sec. 36, T. 23 S., R. 20 E., M. D.	Surveyed		5.76	5.76
Sec. 36, T. 1 S., R. 21 E., M. D.	Surveyed	160		160
Sec. 36, T. 6 S., R. 21 E., M. D.	Surveyed	40		40
Sec. 16, T. 7 S., R. 21 E., M. D.	Surveyed	320		320
Sec. 16, T. 10 S., R. 21 E., M. D.	Surveyed		320	320
Sec. 36, T. 20 S., R. 21 E., M. D.	Surveyed		7.28	7.28
Sec. 16, T. 23 S., R. 21 E., M. D.	Surveyed		.08	.08
Sec. 16, T. 25 S., R. 21 E., M. D.	Surveyed		320	320
Sec 16, T. 7 S., R. 22 E., M. D.	Surveyed	10		10
Sec. 36, T. 7 S., R. 22 E., M. D.	Surveyed	160		160
Sec. 36, T. 9 S., R. 22 E., M. D.	Surveyed	320		320
Sec. 36, T. 10 S., R. 22 E., M. D.	Surveyed		200	200
Sec. 36, T. 14 S., R. 22 E., M. D.	Surveyed		116.23	116.23
Sec. 36, T. 18 S., R. 22 E., M. D.	Surveyed		24.82	24.82
Sec. 16, T. 21 S., R. 22 E., M. D.	Surveyed		13.54	13.54
Sec. 16, T. 26 S., R. 22 E., M. D.	Surveyed		1.50	1.50
Sec. 16, T. 27 S., R. 22 E., M. D.	Surveyed		40	40
Sec. 36, T. 28 S., R. 22 E., M. D.	Surveyed		27.83	27.83
Sec. 16, T. 4 S., R. 23 E., M. D.	Surveyed	40		40
Sec. 36, T. 4 S., R. 23 E., M. D.	Surveyed	640		640
Sec. 16, T. 9 S., R. 23 E., M. D.	Surveyed		160	160
Sec. 36, T. 9 S., R. 23 E., M. D.	Surveyed	400		400
Sec. 16, T. 20 S., R. 23 E., M. D.	Surveyed		45.17	45.17
Sec. 16, T. 22 S., R. 23 E., M. D.	Surveyed		.32	.32
Sec. 36, T. 23 S., R. 23 E., M. D.	Surveyed		284.40	284.40
Sec. 16, T. 25 S., R. 23 S., M. D.	Surveyed		160	160
Sec. 36, T. 3 S., R. 24 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 4 S., R. 24 E., M. D.	Surveyed	3.79		3.79
Sec. 16, T. 7 S., R. 24 E., M. D.	Surveyed	12		12
Sec. 16, T. 8 S., R. 24 E., M. D.	Surveyed	.57		.57
Sec. 36, T. 8 S., R. 24 E., M. D.	Surveyed	40		40
Sec. 36, T. 16 S., R. 24 E., M. D.	Surveyed	320		320
Sec. 36, T. 21 S., R. 24 E., M. D.	Surveyed	80		80
Sec. 16, T. 7 S., R. 25 E., M. D.	Surveyed	400.25		400.25
Sec. 36, T. 8 S., R. 25 E., M. D.	Surveyed	.72		.72
Sec. 16, T. 11 S., R. 25 E., M. D.	Surveyed	440		440
Sec. 36, T. 11 S., R. 25 E., M. D.	Surveyed	400		400
Sec. 16, T. 12 S., R. 25 E., M. D.	Surveyed	320		320
Sec. 36, T. 12 S., R. 25 E., M. D.	Surveyed	640		640
Sec. 16, T. 18 S., R. 25 E., M. D.	Surveyed		50.37	50.37
Sec. 36, T. 20 S., R. 25 E., M. D.	Surveyed		19.84	19.84
Sec. 16, T. 21 S., R. 25 E., M. D.	Surveyed		320	320
Sec. 16, T. 32 S., R. 25 E., M. D.	Surveyed		10	10
Sec. 36, T. 1 S., R. 26 E., M. D.	Surveyed	600		600
Sec. 36, T. 2 S., R. 26 E., M. D.	Surveyed		560	560

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 3 S., R. 26 E., M. D.	Unsurveyed	578.84	
Sec. 36, T. 3 S., R. 26 E., M. D.	Unsurveyed	.90	
Sec. 36, T. 5 S., R. 26 E., M. D.	Unsurveyed	.09	
Sec. 16, T. 6 S., R. 26 E., M. D.	Unsurveyed	40	
Sec. 36, T. 8 S., R. 26 E., M. D.	Surveyed	21.36	
Sec. 36, T. 10 S., R. 26 E., M. D.	Surveyed	45.53	
Sec. 36, T. 11 S., R. 26 E., M. D.	Unsurveyed	.21	
Sec. 16, T. 13 S., R. 26 E., M. D.	Surveyed	.09	
Sec. 36, T. 13 S., R. 26 E., M. D.	Surveyed	320	
Sec. 36, T. 31 S., R. 26 E., M. D.	Surveyed		240
Sec. 16, T. 1 S., R. 27 E., M. D.	Unsurveyed	80.50	
Sec. 36, T. 1 S., R. 27 E., M. D.	Surveyed	40	
Sec. 16, T. 2 S., R. 27 E., M. D.	Surveyed	80	
Sec 16, T. 3 S., R. 27 E., M. D.	Surveyed	142	
Sec. 36, T. 3 S., R. 27 E., M. D.	Surveyed	18	
Sec. 36, T. 4 S., R. 27 E., M. D.	Surveyed	51	
Sec. 16, T. 10 S., R. 27 E., M. D.	Surveyed	.17	
Sec. 36, T. 10 S., R. 27 E., M. D.	Surveyed	26.51	
Sec. 16, T. 14 S., R. 27 E., M. D.	Surveyed	160	
Sec 36, T. 14 S., R. 27 E., M. D.	Surveyed	440	
Sec. 16, T. 15 S., R. 27 E., M. D.	Surveyed	240	
Sec. 36, T. 15 S., R. 27 E., M. D.	Surveyed	200	
Sec. 16, T. 21 S., R. 27 E., M. D.	Surveyed		21.51
Sec. 36, T. 29 S., R. 27 E., M. D.	Surveyed		600
Sec. 16, T. 2 S., R. 28 E., M. D.	Surveyed	200	
Sec. 16, T. 3 S., R. 28 E., M. D.	Surveyed	400	
Sec. 16, T. 4 S., R. 28 E., M. D.	Surveyed	21.76	
Sec. 36, T. 4 S., R. 28 E., M. D.	Surveyed	640	
Sec. 16, T. 5 S., R. 28 E., M. D.	Unsurveyed	116.59	
Sec. 36, T. 5 S., R. 28 E., M. D.	Unsurveyed		27.77
Sec. 16, T. 6 S., R. 28 E., M. D.	Unsurveyed	3.81	
Sec. 16, T. 7 S., R. 28 E., M. D.	Surveyed	1.57	
Sec. 16, T. 9 S., R. 28 E., M. D.	Surveyed	8.15	
Sec. 36, T. 12 S., R. 28 E., M. D.	Surveyed	40	
Sec. 16, T. 15 S., R. 28 E., M. D.	Surveyed	400	
Sec. 36, T. 15 S., R. 28 E., M. D.	Surveyed	40	
Sec. 36, T. 16 S., R. 28 E., M. D.	Surveyed	621.71	
Sec. 16, T. 1 S., R. 29 E., M. D.	Surveyed	200	
Sec. 16, T. 5 S., R. 29 E., M. D.	Surveyed	144.86	
Sec. 36, T. 5 S., R. 29 E., M. D.	Surveyed	17.53	
Sec. 16, T. 7 S., R. 29 E., M. D.	Surveyed	40.49	
Sec. 36, T. 7 S., R. 29 E., M. D.	Surveyed	160	
Sec. 36, T. 8 S., R. 29 E., M. D.	Unsurveyed	.26	
Sec. 16, T. 15 S., R. 29 E., M. D.	Surveyed	91.64	
Sec 36, T. 17 S., R. 29 E., M. D.	Surveyed	280	
Sec. 16, T. 19 S., R. 29 E., M. D.	Surveyed	320	
Sec. 16, T. 1 S., R. 30 E., M. D.	Surveyed	640	
Sec. 36, T. 1 S., R. 30 E., M. D.	Surveyed	360	
Sec. 36, T. 2 S., R. 30 E., M. D.	Surveyed	640	
Sec. 36, T. 3 S., R. 30 E., M. D.	Surveyed	640	
Sec. 16, T. 4 S., R. 30 E., M. D.	Surveyed	551.25	
Sec. 16, T. 5 S., R. 30 E., M. D.	Surveyed	.38	
Sec. 16, T. 7 S., R. 30 E., M. D.	Surveyed	80	
Sec. 16, T. 8 S., R. 30 E., M. D.	Unsurveyed	25.89	
Sec. 16, T. 13 S., R. 30 E., M. D.	Surveyed	120	
Sec. 36, T. 13 S., R. 30 E., M. D.	Surveyed	19.11	
Sec. 16, T. 15 S., R. 30 E., M. D.	Surveyed	28.16	
Sec. 36, T. 15 S., R. 30 E., M. D.	Surveyed	192.20	
Sec. 36, T. 17 S., R. 30 E., M. D.	Surveyed	68.36	
Sec. 16, T. 19 S., R. 30 E., M. D.	Surveyed	.13	

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 21 S., R. 30 E., M. D.	Surveyed	46.52		46.52
Sec. 36, T. 23 S., R. 30 E., M. D.	Surveyed	80		80
Sec. 16, T. 25 S., R. 30 E., M. D.	Surveyed		160	160
Sec. 36, T. 26 S., R. 30 E., M. D.	Surveyed		320	320
Sec. 16, T. 1 S., R. 31 E., M. D.	Surveyed		640	640
Sec. 36, T. 1 S., R. 31 E., M. D.	Surveyed		200	200
Sec. 16, T. 2 S., R. 31 E., M. D.	Surveyed		640	640
Sec. 36, T. 2 S., R. 31 E., M. D.	Surveyed		640	640
Sec. 36, T. 4 S., R. 31 E., M. D.	Surveyed		640	640
Sec. 16, T. 5 S., R. 31 E., M. D.	Surveyed		320	320
Sec. 36, T. 5 S., R. 31 E., M. D.	Surveyed		640	640
Sec. 36, T. 8 S., R. 31 E., M. D.	Surveyed	17.21		17.21
Sec. 36, T. 9 S., R. 31 E., M. D.	Surveyed	14.21		14.21
Sec. 36, T. 11 S., R. 31 E., M. D.	Unsurveyed	2		2
Sec. 36, T. 13 S., R. 31 E., M. D.	Surveyed	159.78		159.78
Sec. 36, T. 15 S., R. 31 E., M. D.	Surveyed	8.15		8.15
Sec. 16, T. 23 S., R. 31 E., M. D.	Surveyed	40		40
Sec. 16, T. 28 S., R. 31 E., M. D.	Surveyed	160		160
Sec. 16, T. 1 S., R. 32 E., M. D.	Surveyed		400	400
Sec. 36, T. 1 S., R. 32 E., M. D.	Surveyed	12.60		12.60
Sec. 16, T. 2 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 36, T. 2 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 16, T. 3 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 16, T. 4 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 16, T. 5 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 36, T. 5 S., R. 32 E., M. D.	Surveyed		480	480
Sec. 16, T. 7 S., R. 32 E., M. D.	Surveyed		80	80
Sec. 36, T. 7 S., R. 32 E., M. D.	Surveyed		640	640
Sec. 36, T. 9 S., R. 32 E., M. D.	Surveyed	54.72		54.72
Sec. 36, T. 10 S., R. 32 E., M. D.	Unsurveyed	2.70		2.70
Sec. 16, T. 11 S., R. 32 E., M. D.	Unsurveyed	.63		.63
Sec. 36, T. 12 S., R. 32 E., M. D.	Unsurveyed	.54		.54
Sec. 16, T. 14 S., R. 32 E., M. D.	Surveyed	15.12		15.12
Sec. 36, T. 14 S., R. 32 E., M. D.	Surveyed	120		120
Sec. 16, T. 15 S., R. 32 E., M. D.	Surveyed	.30		.30
Sec. 16, T. 17 S., R. 32 E., M. D.	Surveyed	4.26		4.26
Sec 36, T. 21 S., R. 32 E., M. D.	Surveyed	.09		.09
Sec. 16, T. 22 S., R. 32 E., M. D.	Surveyed	3.41		3.41
Sec. 36, T. 22 S., R. 32 E., M. D.	Surveyed	1.18		1.18
Sec. 16, T. 29 S., R. 32 E., M. D.	Surveyed	160		160
Sec. 36, T. 29 S., R. 32 E., M. D.	Surveyed	640		640
Sec. 36, T. 30 S., R. 32 E., M. D.	Surveyed	240		240
Sec. 16, T. 2 S., R. 33 E., M. D.	Surveyed	600		600
Sec. 36, T. 2 S., R. 33 E., M. D.	Surveyed		640	640
Sec. 36, T. 6 S., R. 33 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 33 E., M. D.	Surveyed		160	160
Sec. 16, T. 11 S., R. 33 E., M. D.	Surveyed	4.18		4.18
Sec. 36, T. 11 S., R. 33 E., M. D.	Surveyed	2.44		2.44
Sec. 36, T. 21 S., R. 33 E., M. D.	Surveyed	71.78		71.78
Sec. 16, T. 22 S., R. 33 E., M. D.	Surveyed	50.88		50.88
Sec. 16, T. 27 S., R. 33 E., M. D.	Surveyed	.03		.03
Sec. 36, T. 29 S., R. 33 E., M. D.	Surveyed	560		560
Sec. 36, T. 31 S., R. 33 E., M. D.	Surveyed	480		480
Sec. 16, T. 1 S., R. 34 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 1 S., R. 34 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 2 S., R. 34 E., M. D.	Surveyed		15.23	15.23
Sec. 36, T. 3 S., R. 34 E., M. D.	Unsurveyed	40		40
Sec. 36, T. 4 S., R. 34 E., M. D.	Unsurveyed	40		40
Sec. 36, T. 9 S., R. 34 E., M. D.	Surveyed		320	320
Sec. 16, T. 10 S., R. 34 E., M. D.	Surveyed		320	320

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 10 S., R. 34 E., M. D.	Surveyed		600	600
Sec. 16, T. 11 S., R. 34 E., M. D.	Surveyed		480	480
Sec. 16, T. 12 S., R. 34 E., M. D.	Surveyed	160		160
Sec. 36, T. 12 S., R. 34 E., M. D.	Surveyed		160	160
Sec. 16, T. 14 S., R. 34 E., M. D.	Unsurveyed	6.49		6.49
Sec. 16, T. 18 S., R. 34 E., M. D.	Surveyed	240		240
Sec. 16, T. 20 S., R. 34 E., M. D.	Surveyed	40		40
Sec. 16, T. 21 S., R. 34 E., M. D.	Surveyed	640		640
Sec. 16, T. 29 S., R. 34 E., M. D.	Surveyed	238.21		238.21
Sec. 36, T. 29 S., R. 34 E., M. D.	Surveyed	640		640
Sec. 16, T. 30 S., R. 34 E., M. D.	Surveyed	640		640
Sec. 36, T. 31 S., R. 34 E., M. D.	Surveyed	663.84		663.84
Sec. 36, T. 32 S., R. 34 E., M. D.	Surveyed	320		320
Sec. 16, T. 3 S., R. 35 E., M. D.	Surveyed		148.12	148.12
Sec. 16, T. 4 S., R. 35 E., M. D.	Unsurveyed		9.12	9.12
Sec. 16, T. 5 S., R. 35 E., M. D.	Unsurveyed	40		40
Sec. 16, T. 6 S., R. 35 E., M. D.	Surveyed	320		320
Sec. 36, T. 6 S., R. 35 E., M. D.	Surveyed	40		40
Sec. 16, T. 7 S., R. 35 E., M. D.	Surveyed	640		640
Sec. 36, T. 7 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 35 E., M. D.	Surveyed		160	160
Sec. 36, T. 8 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 16, T. 9 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 36, T. 9 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 36, T. 10 S., R. 35 E., M. D.	Unsurveyed	40		40
Sec. 36, T. 11 S., R. 35 E., M. D.	Unsurveyed	.96		.96
Sec. 36, T. 12 S., R. 35 E., M. D.	Surveyed	40.55		40.55
Sec. 36, T. 13 S., R. 35 E., M. D.	Surveyed		40	40
Sec. 16, T. 21 S., R. 35 E., M. D.	Surveyed	71.42		71.42
Sec. 16, T. 24 S., R. 35 E., M. D.	Surveyed	2.40		2.40
Sec. 36, T. 24 S., R. 35 E., M. D.	Surveyed	1.31		1.31
Sec. 36, T. 29 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 36, T. 30 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 16, T. 31 S., R. 35 E., M. D.	Surveyed	41.90		41.90
Sec. 36, T. 31 S., R. 35 E., M. D.	Surveyed	641.54		641.54
Sec. 36, T. 32 S., R. 35 E., M. D.	Surveyed		640	640
Sec. 16, T. 5 S., R. 36 E., M. D.	Surveyed	640		640
Sec. 36, T. 5 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 16, T. 6 S., R. 36 E., M. D.	Surveyed	640		640
Sec. 36, T. 6 S., R. 36 E., M. D.	Surveyed		480	480
Sec. 36, T. 7 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 36, T. 8 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 16, T. 9 S., R. 36 E., M. D.	Surveyed	640		640
Sec. 36, T. 9 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 16, T. 10 S., R. 36 E., M. D.	Surveyed	640		640
Sec. 36, T. 13 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 36, T. 14 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 16, T. 15 S., R. 36 E., M. D.	Surveyed		160	160
Sec. 16, T. 16 S., R. 36 E., M. D.	Surveyed	55.42		55.42
Sec. 36, T. 18 S., R. 36 E., M. D.	Surveyed	480		480
Sec. 16, T. 20 S., R. 36, E., M. D.	Surveyed	.23		.23
Sec. 36, T. 24 S., R. 36 E., M. D.	Surveyed	35		35
Sec. 16, T. 25 S., R. 36 E., M. D.	Surveyed	1.24		1.24
Sec. 16, T. 26 S., R. 36 E., M. D.	Surveyed	.26		.26
Sec. 16, T. 31 S., R. 36 E., M. D.	Surveyed		640	640
Sec. 36, T. 31 S., R. 36 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 6 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 6 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 7 S., R. 37 E., M. D.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 7 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 8 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 9 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 9 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 10 S., R. 37 E., M. D.	Surveyed		160	160
Sec. 16, T. 11 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 11 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 12 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 12 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 13 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 14 S., R. 37 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 14 S., R. 37 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 15 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 15 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 18 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 16, T. 19 S., R. 37 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 19 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 20 S., R. 37 E., M. D.	Surveyed	40		40
Sec. 36, T. 21 S., R. 37 E., M. D.	Surveyed		640	640
Sec. 36, T. 26 S., R. 37 E., M. D.	Surveyed	.86		.86
Sec. 16, T. 27 S., R. 37 E., M. D.	Surveyed	.03		.03
Sec. 36, T. 28 S., R. 37 E., M. D.	Surveyed		17.59	17.59
Sec. 16, T. 30 S., R. 37 E., M. D.	Surveyed		160	160
Sec. 16, T. 5 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 6 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 6 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 7 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 7 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 8 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 9 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 9 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 10 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 10 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 11 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 11 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 12 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 12 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 13 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 13 S., R. 38 E., M. D.	Surveyed		411.56	411.56
Sec. 16, T. 14 S., R. 38 E., M. D.	Surveyed		400	400
Sec. 36, T. 14 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 15 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 15 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 16 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 16 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 17 S., R. 38 E., M. D.	Surveyed		2.09	2.09
Sec. 16, T. 18 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 18 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 19 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 19 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 20 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 20 S., R. 38 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 21 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 21 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 22 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 23 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 36, T. 23 S., R. 38 E., M. D.	Surveyed		640	640
Sec. 16, T. 24 S., R. 38 E., M. D.	Surveyed		23.04	23.04

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 27 S., R. 38 E., M. D.	Surveyed		640
Sec. 16, T. 29 S., R. 38 E., M. D.	Surveyed		640
Sec. 36, T. 30 S., R. 38 E., M. D.	Surveyed		320
Sec. 16, T. 7 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 7 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 8 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 8 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 9 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 10 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 36, T. 10 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 16, T. 11 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 16, T. 12 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 12 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 13 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 13 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 14 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 14 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 15 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 15 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 16 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 36, T. 16 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 16, T. 17 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 36, T. 17 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 16, T. 18 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 18 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 19 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 19 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 20 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 36, T. 20 S., R. 39 E., M. D.	Unsurveyed		640
Sec. 16, T. 21 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 21 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 22 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 22 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 23 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 24 S., R. 39 E., M. D.	Surveyed		640
Sec. 16, T. 29 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 29 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 30 S., R. 39 E., M. D.	Surveyed		640
Sec. 36, T. 32 S., R. 39 E., M. D.	Surveyed		320
Sec. 16, T. 7 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 7 S., R. 40 E., M. D.	Unsurveyed		320
Sec. 16, T. 8 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 8 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 9 S., R. 40 E., M. D.	Surveyed		360.22
Sec 16, T. 10 S., R. 40 E., M. D.	Surveyed		3.06
Sec. 16, T. 11 S., R. 40 E., M. D.	Surveyed		440
Sec. 36, T. 11 S., R. 40 E., M. D.	Surveyed		136.14
Sec. 16, T. 13 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 13 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 16, T. 14 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 14 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 16, T. 15 S., R. 40 E., M. D.	Surveyed		640
Sec 36, T. 15 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 16, T. 16 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 16 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 16, T. 17 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 36, T. 17 S., R. 40 E., M. D.	Unsurveyed		640
Sec. 16, T. 18 S., R. 40 E., M. D.	Surveyed		640
Sec. 36, T. 18 S., R. 40 E., M. D.	Surveyed		640
Sec. 16, T. 19 S., R. 40 E., M. D.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 36, T. 19 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 16, T. 20 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 36, T. 20 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 16, T. 21 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 36, T. 21 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 16, T. 22 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 36, T. 22 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 16, T. 23 S., R. 40 E., M. D.	Surveyed		440	440
Sec. 36, T. 26 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 36, T. 27 S., R. 40 E., M. D.	Surveyed		7.89	7.89
Sec. 16, T. 29 S., R. 40 E., M. D.	Surveyed		640	640
Sec. 16, T. 8 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 8 S., R. 41 E., M. D.	Unsurveyed		639.87	639.87
Sec. 16, T. 9 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 10 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 10 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 11 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 11 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 12 S., R. 41 E., M. D.	Surveyed		40	40
Sec. 36, T. 12 S., R. 41 E., M. D.	Surveyed		155.69	155.69
Sec. 16, T. 13 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 13 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 14 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 14 S., R. 41 E., M. M.	Unsurveyed		640	640
Sec. 16, T. 15 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec 36 T. 15 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 16 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 17 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 18 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 18 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 19 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 19 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 20 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 20 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 21 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 21 S., R. 41 E., M. D.	Surveyed		480	480
Sec. 16, T. 22 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 22 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 23 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 36, T. 23 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 24 S., R. 41 E., M. D.	Surveyed		640	640
Sec. 16, T. 25 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 25 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 26 S., R. 41 E., M. D.	Unsurveyed		279.93	279.93
Sec. 36, T. 26 S., R. 41 E., M. D.	Unsurveyed		41.31	41.31
Sec. 36, T. 29 S., R. 41 E., M. D.	Unsurveyed		520.73	520.73
Sec. 16, T. 30 S., R. 41 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 9 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 9 S., R. 42 E., M. D.	Unsurveyed		106.63	106.63
Sec. 16, T. 10 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 10 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 11 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 11 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 12 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 12 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 13 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 13 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 14 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 36, T. 14 S., R. 42 E., M. D.	Unsurveyed		640	640
Sec. 16, T. 15 S., R. 42 E., M. M.	Unsurveyed		640	640
Sec. 36, T. 15 S., R. 42 E., M. D.	Unsurveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 16 S., R. 42 E., M. D.	Unsurveyed		640
Sec. 36, T. 16 S., R. 42 E., M. D.	Unsurveyed		640
Sec. 16, T. 17 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 17 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 18 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 18 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 19 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 19 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 20 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 20 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 21 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 21 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 22 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 22 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 23 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 23 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 24 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 24 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 25 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 25 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 26 S., R. 42 E., M. D.	Surveyed		640
Sec. 36, T. 26 S., R. 42 E., M. D.	Surveyed		241.36
Sec. 16, T. 27 S., R. 42 E., M. D.	Surveyed		34.02
Sec. 16, T. 28 S., R. 42 E., M. D.	Surveyed		160.24
Sec. 36, T. 28 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 29 S., R. 42 E., M. D.	Surveyed		.14
Sec. 16, T. 30 S., R. 42 E., M. D.	Surveyed		640
Sec. 16, T. 10 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 10 S., R. 43 E., M. D.	Unsurveyed		225.80
Sec. 16, T. 11 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 11 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 12 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 12 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 13 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 13 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 14 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 14 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 15 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 15 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 16 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 16 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 17 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 17 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 18 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 18 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 19 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 20 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 20 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 19 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 21 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 21 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 22 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 22 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 23 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 23 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 24 S., R. 43 E., M. D.	Surveyed		640
Sec. 36, T. 24 S., R. 43 E., M. D.	Surveyed		640
Sec. 16, T. 25 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 25 S., R. 43 E., M. D.	Surveyed		160.85
Sec. 16, T. 26 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 36, T. 26 S., R. 43 E., M. D.	Unsurveyed		640
Sec. 16, T. 27 S., R. 43 E., M. D.	Unsurveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
. 36, T. 27 S., R. 43 E., M. D.	Unsurveyed		640	640
. 16, T. 28 S., R. 43 E., M. D.	Unsurveyed		640	640
. 36, T. 28 S., R. 43 E., M. D.	Unsurveyed		640	640
. 16, T. 29 S., R. 43 E., M. D.	Unsurveyed		640	640
. 36, T. 29 S., R. 43 E., M. D.	Surveyed		640	640
. 16, T. 11 S., R. 44 E., M. D.	Surveyed		245.95	245.95
. 36, T. 11 S., R. 44 E., M. D.	Surveyed		362.89	362.89
. 16, T. 12 S., R. 44 E., M. D.	Surveyed		640	640
. 36, T. 12 S., R. 44 E., M. D.	Surveyed		640	640
. 16, T. 13 S., R. 44 E., M. D.	Surveyed		640	640
. 36, T. 13 S., R. 44 E., M. D.	Surveyed		640	640
. 16, T. 14 S., R. 44 E., M. D.	Surveyed		640	640
. 36, T. 15 S., R. 44 E., M. D.	Surveyed		640	640
. 16, T. 16 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 17 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 18 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 18 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 19 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 19 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 20 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 21 S., R. 44 E., M. D.	Surveyed		120	120
. 36, T. 31 S., R. 44 E., M. D.	Surveyed		640	640
. 16, T. 22 S., R. 44 E., M. D.	Surveyed		640	640
. 36, T. 22 S., R. 44 E., M. D.	Surveyed		600	600
. 16, T. 23 S., R. 44 E., M. D.	Surveyed		560	560
. 36, T. 23 S., R. 44 E., M. D.	Surveyed		280	280
. 16, T. 24 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 24 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 25 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 25 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 26 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 26 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 27 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 27 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 28 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 28 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 30 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 30 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 31 S., R. 44 E., M. D.	Unsurveyed		640	640
. 36, T. 31 S., R. 44 E., M. D.	Unsurveyed		640	640
. 16, T. 12 S., R. 45 E., M. D.	Surveyed		453.17	453.17
. 36, T. 12 S., R. 45 E., M. D.	Surveyed		455.20	455.20
. 16, T. 13 S., R. 45 E., M. D.	Surveyed		.13	.13
. 36, T. 13 S., R. 45 E., M. D.	Surveyed		640	640
. 16, T. 14 S., R. 45 E., M. D.	Surveyed		640	640
. 36, T. 14 S., R. 45 E., M. D.	Surveyed		640	640
. 16, T. 15 S., R. 45 E., M. D.	Surveyed		600.62	600.62
. 36, T. 15 S., R. 45 E., M. D.	Surveyed		640	640
. 16, T. 16 S., R. 45 E., M. D.	Surveyed		5.69	5.69
. 36, T. 16 S., R. 45 E., M. D.	Surveyed		640	640
. 16, T. 17 S., R. 45 E., M. D.	Unsurveyed		640	640
. 36, T. 17 S., R. 45 E., M. D.	Unsurveyed		640	640
. 16, T. 18 S., R. 45 E., M. D.	Unsurveyed		640	640
. 36, T. 18 S., R. 45 E., M. D.	Unsurveyed		640	640
. 16, T. 19 S., R. 45 E., M. D.	Unsurveyed		640	640
. 36, T. 19 S., R. 45 E., M. D.	Unsurveyed		640	640
. 16, T. 20 S., R. 45 E., M. D.	Unsurveyed		640	640
. 36, T. 20 S., R. 45 E., M. D.	Unsurveyed		640	640
. 16, T. 21 S., R. 45 E., M. D.	Unsurveyed		640	640
. 36, T. 21 S., R. 45 E., M. D.	Unsurveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 22 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 22 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 23 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 23 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 24 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 24 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 25 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 25 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 26 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 26 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 27 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 27 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 28 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 28 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 29 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 29 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 30 S., R. 45 E., M. D.	Surveyed		640
Sec. 16, T. 31 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 31 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 32 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 36, T. 32 S., R. 45 E., M. D.	Unsurveyed		640
Sec. 16, T. 14 S., R. 46 E., M. D.	Surveyed		640
Sec. 16, T. 15 S., R. 46 E., M. D.	Surveyed		640
Sec. 36, T. 15 S., R. 46 E., M. D.	Surveyed		122.36
Sec. 16, T. 16 S., R. 46 E., M. D.	Surveyed		640
Sec. 36, T. 16 S., R. 46 E., M. D.	Surveyed		17.32
Sec. 16, T. 17 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 17 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 18 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 18 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 19 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 19 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 20 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 20 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 21 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 21 S., R. 46 E., M. D.	Unsurveyed		597.01
Sec. 16, T. 22 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 22 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 23 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 23 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 24 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 24 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 25 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 26 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 27 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 27 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 28 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 28 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 29 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 29 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 30 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 36, T. 30 S., R. 46 E., M. D.	Unsurveyed		640
Sec. 16, T. 13 S., R. 47 E., M. D.	Unsurveyed		360
Sec. 16, T. 23 S., R. 47 E., M. D.	Surveyed		111
Sec. 16, T. 25 S., R. 47 E., M. D.	Surveyed		640
Sec. 36, T. 25 S., R. 47 E., M. D.	Unsurveyed		368.99
Sec. 16, T. 27 S., R. 47 E., M. D.	Unsurveyed		375.80
Sec 36, T. 2 N., R. 1 E., S. B.	Surveyed	.71	
Sec. 36, T. 4 N., R. 1 E., S. B.	Surveyed		640
Sec. 16, T. 6 N., R 1 E., S. B.	Unsurveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
6 N., R. 1 E., S. B.	Unsurveyed		640	640
7 N., R. 1 E., S. B.	Surveyed		320	320
7 N., R. 1 E., S. B.	Surveyed		640	640
8 N., R. 1 E., S. B.	Surveyed		640	640
1 N., R. 1 E., S. B.	Surveyed		480	480
1 N., R. 1 E., S. B.	Surveyed		640	640
2 N., R. 1 E., S. B.	Surveyed		640	640
2 N., R. 1 E., S. B.	Surveyed		640	640
3 N., R. 1 E., S. B.	Surveyed		640	640
5 N., R. 1 E., S. B.	Surveyed		640	640
6 N., R. 1 E., S. B.	Surveyed		320	320
6 N., R. 1 E., S. B.	Surveyed		640	640
7 N., R. 1 E., S. B.	Surveyed		640	640
7 N., R. 1 E., S. B.	Surveyed		320	320
8 N., R. 1 E., S. B.	Unsurveyed		640	640
8 N., R. 1 E., S. B.	Unsurveyed		640	640
9 N., R. 1 E., S. B.	Surveyed		640	640
9 N., R. 1 E., S. B.	Surveyed		640	640
0 N., R. 1 E., S. B.	Surveyed		640	640
1 N., R. 1 E., S. B.	Surveyed		640	640
1 N., R. 1 E., S. B.	Surveyed		640	640
2 N., R. 1 E., S. B.	Surveyed		640	640
2 N., R. 1 E., S. B.	Surveyed		640	640
3 N., R. 1 E., S. B.	Surveyed		560	560
3 N., R. 1 E., S. B.	Surveyed		640	640
4 N., R. 1 E., S. B.	Surveyed		519.85	519.85
4 N., R. 1 E., S. B.	Surveyed		520	520
5 N., R. 1 E., S. B.	Surveyed		640	640
5 N., R. 1 E., S. B.	Surveyed		640	640
6 N., R. 1 E., S. B.	Surveyed		640	640
6 N., R. 1 E., S. B.	Surveyed		640	640
7 N., R. 1 E., S. B.	Surveyed		84.93	84.93
8 N., R. 1 E., S. B.	Surveyed		640	640
8 N., R. 1 E., S. B.	Surveyed		320	320
9 N., R. 1 E., S. B.	Surveyed		640	640
9 N., R. 1 E., S. B.	Surveyed		640	640
0 N., R. 1 E., S. B.	Surveyed		6.39	6.39
1 N., R. 2 E., S. B.	Surveyed	81.08		81.08
5 N., R. 2 E., S. B.	Surveyed		320	320
5 N., R. 2 E., S. B.	Surveyed		640	640
6 N., R. 2 E., S. B.	Surveyed		640	640
6 N., R. 2 E., S. B.	Surveyed		160	160
7 N., R. 2 E., S. B.	Surveyed		640	640
8 N., R. 2 E., S. B.	Unsurveyed		640	640
8 N., R. 2 E., S. B.	Unsurveyed		640	640
1 N., R. 2 E., S. B.	Surveyed		560	560
2 N., R. 2 E., S. B.	Surveyed		640	640
3 N., R. 2 E., S. B.	Surveyed		640	640
4 N., R. 2 E., S. B.	Surveyed		320	320
5 N., R. 2 E., S. B.	Surveyed		640	640
6 N., R. 2 E., S. B.	Surveyed		640	640
5 N., R. 2 E., S. B.	Surveyed		640	640
6 N., R. 2 E., S. B.	Surveyed		640	640
7 N., R. 2 E., S. B.	Surveyed		640	640
7 N., R. 2 E., S. B.	Surveyed		640	640
8 N., R. 2 E., S. B.	Surveyed		640	640
8 N., R. 2 E., S. B.	Surveyed		640	640
9 N., R. 2 E., S. B.	Surveyed		640	640
9 N., R. 2 E., S. B.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 20 N., R. 2 E., S. B.	Unsurveyed		640
Sec. 36, T. 20 N., R. 2 E., S. B.	Unsurveyed		640
Sec. 16, T. 21 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 21 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 22 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 22 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 23 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 23 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 24 N., R. 2 E., S. B.	Surveyed		639.54
Sec. 36, T. 24 N., R. 2 E., S. B.	Surveyed		480
Sec. 16, T. 25 N., R. 2 E., S. B.	Surveyed		392.43
Sec. 36, T. 25 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 26 N., R. 2 E., S. B.	Surveyed		560
Sec. 16, T. 27 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 27 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 28 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 28 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 29 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 29 N., R. 2 E., S. B.	Surveyed		640
Sec. 16, T. 30 N., R. 2 E., S. B.	Surveyed		640
Sec. 36, T. 1 N., R. 3 E., S. B.	Surveyed	.64	
Sec. 36, T. 2 N., R. 3 E., S. B.	Surveyed	.02	
Sec. 16, T. 3 N., R. 3 E., S. B.	Surveyed	640	
Sec. 36, T. 4 N., R. 3 E., S. B.	Surveyed		160
Sec. 16, T. 5 N., R. 3 E., S. B.	Surveyed		480
Sec. 36, T. 5 N., R. 3 E., S. B.	Surveyed		480
Sec. 16, T. 6 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 36, T. 6 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 16, T. 7 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 16, T. 12 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 12 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 14 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 3 E., S. B.	Surveyed		160
Sec. 16, T. 15 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 15 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 16 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 16 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 17 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 17 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 18 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 18 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 19 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 19 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 20 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 36, T. 20 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 16, T. 21 N., R. 3 E., S. B.	Surveyed		640
Sec. 36, T. 21 N., R. 3 E., S. B.	Surveyed		640
Sec. 16, T. 22 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 36, T. 22 N., R. 3 E., S. B.	Unsurveyed		640
Sec. 16, T. 23 N., R. 3 E., S. B.	Surveyed		160
Sec. 36, T. 23 N., R. 3 E., S. B.	Surveyed		160
Sec. 16, T. 24 N., R. 3 E., S. B.	Surveyed		559.77
Sec. 36, T. 24 N., R. 3 E., S. B.	Surveyed		560
Sec. 16, T. 25 N., R. 3 E., S. B.	Surveyed		560
Sec. 36, T. 25 N., R. 3 E., S. B.	Surveyed		560
Sec. 16, T. 26 N., R. 3 E., S. B.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1913.
26 N., R. 3 E., S. B.	Surveyed		640	640
27 N., R. 3 E., S. B.	Surveyed		640	640
27 N., R. 3 E., S. B.	Surveyed		320	320
28 N., R. 3 E., S. B.	Surveyed		640	640
28 N., R. 3 E., S. B.	Surveyed		320	320
1 N., R. 4 E., S. B.	Surveyed		.08	.08
2 N., R. 4 E., S. B.	Unsurveyed		.10	.10
3 N., R. 4 E., S. B.	Unsurveyed		640	640
4 N., R. 4 E., S. B.	Unsurveyed		480	480
4 N., R. 4 E., S. B.	Unsurveyed		640	640
5 N., R. 4 E., S. B.	Unsurveyed		640	640
5 N., R. 4 E., S. B.	Unsurveyed		640	640
6 N., R. 4 E., S. B.	Unsurveyed		640	640
7 N., R. 4 E., S. B.	Unsurveyed		640	640
7 N., R. 4 E., S. B.	Unsurveyed		640	640
10 N., R. 4 E., S. B.	Surveyed		640	640
12 N., R. 4 E., S. B.	Surveyed		640	640
12 N., R. 4 E., S. B.	Surveyed		640	640
13 N., R. 4 E., S. B.	Surveyed		640	640
13 N., R. 4 E., S. B.	Surveyed		640	640
14 N., R. 4 E., S. B.	Surveyed		640	640
14 N., R. 4 E., S. B.	Surveyed		640	640
15 N., R. 4 E., S. B.	Surveyed		640	640
15 N., R. 4 E., S. B.	Surveyed		640	640
16 N., R. 4 E., S. B.	Surveyed		160	160
16 N., R. 4 E., S. B.	Surveyed		320	320
17 N., R. 4 E., S. B.	Unsurveyed		640	640
17 N., R. 4 E., S. B.	Unsurveyed		640	640
18 N., R. 4 E., S. B.	Surveyed		640	640
18 N., R. 4 E., S. B.	Surveyed		640	640
19 N., R. 4 E., S. B.	Surveyed		640	640
19 N., R. 4 E., S. B.	Surveyed		640	640
20 N., R. 4 E., S. B.	Surveyed		640	640
20 N., R. 4 E., S. B.	Surveyed		280	280
21 N., R. 4 E., S. B.	Surveyed		640	640
21 N., R. 4 E., S. B.	Surveyed		640	640
22 N., R. 4 E., S. B.	Surveyed		640	640
22 N., R. 4 E., S. B.	Surveyed		640	640
23 N., R. 4 E., S. B.	Surveyed		640	640
23 N., R. 4 E., S. B.	Surveyed		640	640
24 N., R. 4 E., S. B.	Surveyed		560	560
24 N., R. 4 E., S. B.	Surveyed		560	560
25 N., R. 4 E., S. B.	Surveyed		640	640
25 N., R. 4 E., S. B.	Surveyed		640	640
26 N., R. 4 E., S. B.	Surveyed		640	640
26 N., R. 4 E., S. B.	Surveyed		640	640
27 N., R. 4 E., S. B.	Surveyed		640	640
1 N., R. 5 E., S. B.	Surveyed		600	600
1 N., R. 5 E., S. B.	Surveyed		161.51	161.51
2 N., R. 5 E., S. B.	Surveyed		640	640
2 N., R. 5 E., S. B.	Surveyed		640	640
3 N., R. 5 E., S. B.	Surveyed		640	640
3 N., R. 5 E., S. B.	Surveyed		640	640
4 N., R. 5 E., S. B.	Unsurveyed		640	640
4 N., R. 5 E., S. B.	Unsurveyed		640	640
5 N., R. 5 E., S. B.	Surveyed		640	640
5 N., R. 5 E., S. B.	Surveyed		640	640
6 N., R. 5 E., S. B.	Surveyed		640	640
6 N., R. 5 E., S. B.	Surveyed		640	640
7 N., R. 5 E., S. B.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 36, T. 7 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 10 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 10 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 11 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 12 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 13 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 14 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 15 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 15 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 16 N., R. 5 E., S. B.	Surveyed		320
Sec. 36, T. 16 N., R. 5 E., S. B.	Unsurveyed		640
Sec. 16, T. 17 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 17 N., R. 5 E., S. B.	Surveyed		640
Sec 16, T. 18 N., R. 5 E., S. B.	Surveyed		160
Sec. 36, T. 18 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 19 N., R. 5 E., S. B.	Surveyed		640
Sec 36, T. 19 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 20 N., R. 5 E., S. B.	Unsurveyed		640
Sec. 36, T. 20 N., R. 5 E., S. B.	Unsurveyed		640
Sec. 16, T. 21 N., R 5 E., S. B.	Surveyed		640
Sec. 36, T. 21 N., R. 5 E., S. B.	Surveyed		640
Sec 16, T. 22 N., R. 5 E, S. B.	Surveyed		640
Sec. 36, T. 22 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 23 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 23 N., R. 5 E., S. B.	Surveyed		640
Sec. 16, T. 24 N., R 5 E., S. B.	Surveyed		640
Sec. 36, T. 24 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 25 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 26 N., R. 5 E., S. B.	Surveyed		640
Sec. 36, T. 1 N., R. 6 E., S. B.	Surveyed		40
Sec. 36, T. 3 N., R. 6 E., S. B.	Surveyed		160
Sec. 16, T. 4 N., R. 6 E., S. B.	Surveyed		640
Sec. 36, T. 4 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 5 N., R. 6 E., S. B.	Surveyed		640
Sec. 36, T. 5 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 6 N., R. 6 E., S. B.	Surveyed		640
Sec. 36, T. 6 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 7 N., R. 6 E., S. B.	Surveyed		480
Sec. 36, T. 7 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 9 N., R. 6 E., S. B.	Unsurveyed		640
Sec. 36, T. 9 N., R. 6 E., S. B.	Unsurveyed		640
Sec. 16, T. 10 N., R. 6 E., S. B.	Unsurveyed		640
Sec. 36, T. 10 N., R. 6 E., S. B.	Unsurveyed		640
Sec. 16, T. 11 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 6 E., S. B.	Surveyed		640
Sec 36, T. 12 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 6 E., S. B.	Surveyed		160
Sec 36, T. 13 N., R. 6 E., S. B.	Surveyed		160
Sec. 16, T. 14 N., R. 6 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 15 N., R. 6 E., S. B.	Surveyed		640
Sec 36, T. 15 N., R. 6 E., S. B.	Surveyed		640
Sec. 16, T. 16 N., R 6 E., S. B.	Surveyed		480
Sec 36, T. 16 N., R. 6 E, S. B.	Surveyed		640
Sec. 16, T. 17 N., R. 6 E., S. B.	Unsurveyed		640
Sec. 36, T. 17 N., R. 6 E., S. B.	Unsurveyed		640
Sec 16, T. 18 N., R. 6 E., S. B.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R 6 E, S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Unsurveyed		640	640
N., R. 6 E., S. B.	Unsurveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		640	640
N., R. 6 E., S. B.	Surveyed		628.06	628.06
N., R. 6 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Unsurveyed		640	640
., R. 7 E., S. B.	Unsurveyed		640	640
., R. 7 E., S. B.	Unsurveyed		640	640
., R. 7 E., S. B.	Unsurveyed		640	640
., R. 7 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Surveyed		640	640
., R. 7 E., S. B.	Surveyed		480	480
., R. 7 E., S. B.	Surveyed		160	160
., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		160	160
N., R. 7 E., S. B.	Surveyed		320	320
N., R. 7 E., S. B.	Surveyed		24.26	24.26
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Unsurveyed		640	640
N., R. 7 E. S. B.	Unsurveyed		640	640
N., R. 7 E. S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Unsurveyed		640	640
N., R. 7 E., S. B.	Unsurveyed		640	640
N., R. 7 E., S. B.	Surveyed		40.30	40.30
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 7 E., S. B.	Surveyed		640	640
N., R. 8 E., S. B.	Unsurveyed		640	640
N., R. 8 E., S. B.	Unsurveyed		640	640
N., R. 8 E., S. B.	Unsurveyed		640	640
N., R. 8 E., S. B.	Unsurveyed		640	640
N., R. 8 E., S. B.	Unsurveyed		640	640
N				

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outsi National Forest Reserve.
Sec. 36, T. 6 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 8 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 9 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 9 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 16, T. 10 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 10 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 11 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 13 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 14 N., R. 8 E., S. B.	Surveyed		640
Sec 36, T. 14 N., R. 8 E., S. B.	Surveyed		320
Sec. 36, T. 15 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 16 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 16 N., R. 8 E., S. B.	Surveyed		640
Sec 16, T. 17 N., R. 8 E., S. B.	Surveyed		640
Sec 36, T. 17 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 18 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 18 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 19 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 19 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 20 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 20 N., R. 8 E., S. B.	Unsurveyed		640
Sec. 16, T. 21 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 21 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 22 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 22 N., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 23 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 23 N., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 1 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 2 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 2 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 3 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 3 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 4 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 4 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 5 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 5 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 6 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 6 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 7 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 9 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 9 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 10 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 10 N., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 11 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 12 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 13 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 14 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 15 N., R. 9 E., S. B.	Surveyed		320
Sec. 36, T. 15 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 16 N., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 16 N., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 17 N., R. 9 E., S. B.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
17 N., R. 9 E., S. B.	Surveyed		640	640
18 N., R. 9 E., S. B.	Surveyed		640	640
18 N., R. 9 E., S. B.	Surveyed		640	640
19 N., R. 9 E., S. B.	Unsurveyed		640	640
19 N., R. 9 E., S. B.	Unsurveyed		640	640
20 N, R. 9 E., S. B.	Unsurveyed		640	640
20 N., A. 9 E., S. B.	Unsurveyed		640	640
21 N., R. 9 E., S. B.	Surveyed		640	640
21 N., R. 9 E., S. B.	Surveyed		640	640
22 N., R. 9 E., S. B.	Surveyed		640	640
22 N., R. 9 E., S. B.	Surveyed		640	640
23 N., R. 9 E., S. B.	Surveyed		5.99	5.99
2 N., R. 10 E., S. B.	Surveyed		640	640
3 N., R. 10 E., S. B.	Unsurveyed		640	640
3 N., R. 10 E., S. B.	Unsurveyed		640	640
4 N., R. 10 E., S. B.	Unsurveyed		640	640
4 N., R. 10 E., S. B.	Unsurveyed		640	640
5 N., R. 10 E., S. B.	Surveyed		640	640
5 N., R. 10 E., S. B.	Surveyed		640	640
6 N., R. 10 E., S. B.	Surveyed		640	640
7 N., R. 10 E., S. B.	Unsurveyed		640	640
7 N., R. 10 E., S. B.	Unsurveyed		640	640
8 N., R. 10 E., S. B.	Unsurveyed		640	640
8 N., R. 10 E., S. B.	Unsurveyed		640	640
9 N., R. 10 E., S. B.	Surveyed		640	640
9 N., R. 10 E., S. B.	Surveyed		640	640
10 N., R. 10 E., S. B.	Surveyed		640	640
10 N., R. 10 E., S. B.	Surveyed		640	640
11 N., R. 10 E., S. B.	Surveyed		640	640
12 N., R. 10 E., S. B.	Surveyed		640	640
13 N., R. 10 E., S. B.	Surveyed		640	640
13 N., R. 10 E., S. B.	Unsurveyed		640	640
14 N., R. 10 E., S. B.	Unsurveyed		640	640
14 N., R. 10 E., S. B.	Surveyed		640	640
15 N., R. 10 E., S. B.	Surveyed		640	640
15 N., R. 10 E., S. B.	Surveyed		640	640
16 N., R. 10 E., S. B.	Unsurveyed		640	640
16 N., R. 10 E., S. B.	Unsurveyed		640	640
17 N., R. 10 E., S. B.	Surveyed		640	640
17 N., R. 10 E., S. B.	Surveyed		640	640
18 N., R. 10 E., S. B.	Surveyed		640	640
18 N., R. 10 E., S. B.	Surveyed		640	640
19 N., R. 10 E., S. B.	Unsurveyed		640	640
19 N., R. 10 E., S. B.	Unsurveyed		640	640
20 N., R. 10 E., S. B.	Unsurveyed		640	640
20 N., R. 10 E., S. B.	Unsurveyed		640	640
21 N., R. 10 E., S. B.	Surveyed		640	640
21 N., R. 10 E., S. B.	Surveyed		640	640
22 N., R. 10 E., S. B.	Surveyed		5.22	5.22
1 N., R. 11 E., S. B.	Surveyed		640	640
2 N., R. 11 E., S. B.	Surveyed		640	640
2 N., R. 11 E., S. B.	Surveyed		640	640
3 N., R. 11 E., S. B.	Unsurveyed		640	640
3 N., R. 11 E., S. B.	Unsurveyed		640	640
4 N., R. 11 E., S. B.	Surveyed		640	640
4 N., R. 11 E., S. B.	Surveyed		640	640
5 N., R. 11 E., S. B.	Surveyed		640	640
5 N., R. 11 E., S. B.	Surveyed		640	640
6 N., R. 11 E., S. B.	Unsurveyed		640	640
6 N., R. 11 E., S. B.	Unsurveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 7 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 N., R. 11 E., S. B.	Unsurveyed		640
Sec 36, T. 8 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 9 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 9 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 10 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 10 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 11 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 11 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 12 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 13 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 14 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 15 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 15 N., R. 11 E., S. B.	Surveyed		640
Sec 16, T. 16 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 16 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 17 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 17 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 18 N., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 18 N., R. 11 E., S. B.	Surveyed		640
Sec. 16, T. 19 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 19 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 20 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 20 N., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 21 N., R. 11 E., S. B.	Surveyed		1.46
Sec. 16, T. 2 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 2 N., R. 12 E., S. B.	Surveyed		640
Sec 16, T. 3 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 3 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 4 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 5 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 6 N., R. 12 E., S. B.	Surveyed		640
Sec 36, T. 6 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 7 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 7 N., R. 12 E., S. B.	Surveyed		640
Sec 16, T. 8 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 8 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 9 N.. R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 9 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 10 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 10 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 11 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 11 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 12 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 12 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 13 N., R. 12 E., S. B.	Surveyed		640
Sec 36. T. 13 N., R. 12 E., S. B.	Surveyed		560
Sec. 16, T. 14 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 14 N., R. 12 E., S. B.	Surveyed		640
Sec 16, T. 16 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 16 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 17 N., R. 12 E., S. B.	Surveyed		640
Sec. 16, T. 18 N., R. 12 E., S. B.	Surveyed		640
Sec 36, T. 18 N., R. 12 E., S. B.	Surveyed		640
Sec. 36, T. 19 N., R. 12 E., S. B.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
T. 20 N., R. 12 E., S. B.	Surveyed		.26	.26
T. 1 N., R. 13 E., S. B.	Unsurveyed		640	640
T. 1 N., R. 13 E., S. B.	Unsurveyed		640	640
T. 2 N., R. 13 E., S. B.	Surveyed		640	640
T. 2 N., R. 13 E., S. B.	Surveyed		640	640
T. 3 N., R. 13 E., S. B.	Surveyed		320	320
T. 4 N., R. 13 E., S. B.	Surveyed		640	640
T. 4 N., R. 13 E., S. B.	Surveyed		640	640
T. 6 N., R. 13 E., S. B.	Surveyed		640	640
T. 6 N., R. 13 E., S. B.	Surveyed		640	640
T. 7 N., R. 13 E., S. B.	Surveyed		640	640
T. 7 N., R. 13 E., S. B.	Surveyed		640	640
T. 8 N., R. 13 E., S. B.	Surveyed		640	640
T. 8 N., R. 13 E., S. B.	Surveyed		640	640
T. 9 N., R. 13 E., S. B.	Surveyed		640	640
T. 9 N., R. 13 E., S. B.	Surveyed		640	640
T. 10 N., R. 13 E., S. B.	Surveyed		640	640
T. 10 N., R. 13 E., S. B.	Surveyed		640	640
T. 11 N., R. 13 E., S. B.	Surveyed		640	640
T. 11, N. R. 13 E., S. B.	Surveyed		640	640
T. 12 N., R. 13 E., S. B.	Surveyed		640	640
T. 13 N., R. 13 E., S. B.	Surveyed		640	640
T. 15 N., R. 13 E., S. B.	Surveyed		640	640
T. 15 N., R. 13 E., S. B.	Surveyed		640	640
T. 16 N., R. 13 E., S. B.	Surveyed		640	640
T. 16 N., R. 13 E., S. B.	Surveyed		640	640
T. 17 N., R. 13 E., S. B.	Unsurveyed		640	640
T. 17 N., R. 13 E., S. B.	Unsurveyed		640	640
T. 18 N., R. 13 E., S. B.	Surveyed		640	640
T. 18 N., R. 13 E., S. B.	Surveyed		640	640
T. 1 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 1 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 2 N., R. 14 E., S. B.	Surveyed		640	640
T. 2 N., R. 14 E., S. B.	Surveyed		640	640
T. 4 N., R. 14 E., S. B.	Surveyed		640	640
T. 6 N., R. 14 E., S. B.	Surveyed		640	640
T. 6 N., R. 14 E., S. B.	Surveyed		640	640
T. 7 N., R. 14 E. S. B.	Surveyed		640	640
T. 7 N., R. 14 E., S. B.	Surveyed		640	640
T. 8 N., R. 14 E., S. B.	Surveyed		640	640
T. 8 N., R. 14 E., S. B.	Surveyed		640	640
T. 9 N., R. 14 E., S. B.	Surveyed		640	640
T. 9 N., R. 14 E., S. B.	Surveyed		640	640
T. 10 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 10 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 11 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 11 N., R. 14 E., S. B.	Unsurveyed		640	640
T. 12 N., R. 14 E., S. B.	Surveyed		640	640
T. 12 N., R. 14 E., S. B.	Surveyed		640	640
T. 13 N., R. 14 E., S. B.	Surveyed		640	640
T. 13 N., R. 14 E., S. B.	Surveyed		640	640
T. 15 N., R. 14 E., S. B.	Surveyed		640	640
T. 16 N., R. 14 E., S. B.	Surveyed		640	640
T. 16 N., R. 14 E., S. B.	Surveyed		640	640
T. 17 N., R. 14 E., S. B.	Surveyed		640	640
T. 17 N., R. 14 E., S. B.	Surveyed		640	640
T. 2 N., R. 15 E., S. B.	Surveyed		468.20	468.20
T. 2 N., R. 15 E., S. B.	Surveyed		479.93	479.93
T. 3 N., R. 15 E., S. B.	Surveyed		640	640
T. 4 N., R. 15 E., S. B.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	T b to Ap
Sec 36, T. 4 N., R. 15 E., S. B.	Surveyed		640	
Sec 16, T. 5 N., R. 15 E., S. B.	Unsurveyed		640	
Sec. 36, T. 5 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 6 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 7 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 8 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 8 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 9 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 9 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 10 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 10 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 11 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 11 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 12 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 12 N., R. 15 E., E. B.	Surveyed		640	
Sec. 16, T. 13 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 13 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 14 N., R. 15 E., S. B.	Surveyed		640	
Sec. 36, T. 14 N., R. 15 E., S. B.	Surveyed		603.19	
Sec. 36, T. 16 N., R. 15 E., S. B.	Surveyed		640	
Sec. 16, T. 1 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 1 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 2 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 3 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 5 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 6 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 6 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 7 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 7 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 8 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 8 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 9 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 10 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 10 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 11 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 11 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 12 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 14 N., R. 16 E., S. B.	Surveyed		640	
Sec. 36, T. 15 N., R. 16 E., S. B.	Surveyed		640	
Sec. 16, T. 1 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 1 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 2 N., R. 17 E., S. B.	Surveyed		640	
Sec. 16, T. 3 N., R. 17 E., S. B.	Surveyed		640	
Sec. 36, T. 3 N., R. 17 E., S. B.	Surveyed		640	
Sec. 16, T. 4 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 4 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 16, T. 5 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 5 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 16, T. 6 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 6 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 16, T. 7 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 36, T. 7 N., R. 17 E., S. B.	Unsurveyed		640	
Sec. 16, T. 8 N., R. 17 E., S. B.	Surveyed		640	
Sec. 36, T. 8 N., R. 17 E., S. B.	Surveyed		640	
Sec. 16, T. 9 N., R. 17 E., S. B.	Surveyed		640	
Sec. 36, T. 9 N., R. 17 E., S. B.	Surveyed		640	
Sec. 16, T. 10 N., R. 17 E., S. B.	Surveyed		640	
Sec. 36, T. 10 N., R. 17 E., S. B.	Surveyed		640	
Sec. 16, T. 11 N., R. 17 E., S. B.	Surveyed		160	
Sec. 36, T. 12 N., R. 17 E., S. B.	Surveyed		640	

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
N., R. 17 E., S. B.	Surveyed		640	640
N., R. 17 E., S. B.	Surveyed		640	640
N., R. 17 E., S. B.	Surveyed		320	320
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		160	160
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Unsurveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 18 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Unsurveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 19 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Surveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640
N., R. 20 E., S. B.	Unsurveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.
Sec. 16, T. 10 N., R. 20 E., S. B.	Unsurveyed		640
Sec. 36, T. 10 N., R. 20 E., S. B.	Unsurveyed		640
Sec. 16, T. 11 N., R. 20 E., S. B.	Surveyed		640
Sec. 36, T. 11 N., R. 20 E., S. B.	Surveyed		640
Sec. 16, T. 1 N., R. 21 E., S. B.	Unsurveyed		640
Sec. 16, T. 2 N., R. 21 E., S. B.	Unsurveyed		640
Sec. 16, T. 3 N., R. 21 E., S. B.	Unsurveyed		640
Sec. 36, T. 3 N., R. 21 E., S. B.	Unsurveyed		640
Sec. 16, T. 4 N., R. 21 E., S. B.	Unsurveyed		640
Sec. 16, T. 5 N., R. 21 E., S. B.	Surveyed		640
Sec. 36, T. 6 N., R. 21 E., S. B.	Surveyed		640
Sec. 16, T. 7 N., R. 21 E., S. B.	Surveyed		640
Sec 36, T. 7 N, R. 21 E., S. B.	Surveyed		640
Sec. 16, T. 8 N., R. 21 E., S. B.	Surveyed		640
Sec. 36, T. 8 N., R. 21 E., S. B.	Surveyed		640
Sec. 16, T. 9 N., R. 21 E., S. B.	Surveyed		640
Sec. 36, T. 9 N., R. 21 E., S. B.	Surveyed		640
Sec. 16, T. 10 N., R. 21 E., S. B.	Surveyed		640
Sec. 36, T. 10 N., R. 21 E., S. B.	Surveyed		320
Sec. 16, T. 5 N., R. 22 E., S. B.	Surveyed		640
Sec. 36, T. 6 N., R. 22 E., S. B.	Surveyed		640
Sec. 16, T. 7 N., R. 22 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 N., R. 22 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 N., R. 22 E., S. B.	Surveyed		640
Sec. 36, T. 8 N., R. 22 E., S. B.	Surveyed		640
Sec 16, T. 9 N., R. 22 E., S. B.	Surveyed		640
Sec. 36, T. 9 N., R. 22 E., S. B.	Surveyed		440
Sec. 36, T. 10 N., R. 22 E., S. B.	Surveyed		360.07
Sec. 16, T. 2 N., R. 23 E., S. B.	Unsurveyed		640
Sec. 16, T. 3 N., R. 23 E., S. B.	Unsurveyed		640
Sec. 36, T. 3 N., R. 23 E., S. B.	Surveyed		640
Sec. 16, T. 5 N., R. 23 E., S. B.	Surveyed		640
Sec. 36, T. 5 N., R. 23 E., S. B.	Surveyed		640
Sec 16, T. 6 N., R. 23 E., S. B.	Surveyed		640
Sec 36, T. 6 N., R 23 E., S. B.	Surveyed		640
Sec. 16, T. 7 N., R. 23 E., S. B.	Surveyed		320
Sec. 36, T. 7 N., R. 23 E., S. B.	Surveyed		640
Sec. 16, T. 2 N., R. 24 E., S. B.	Unsurveyed		640
Sec. 36, T. 2 N., R. 24 E., S. B.	Unsurveyed		640
Sec. 16, T. 3 N., R. 24 E., S. B.	Unsurveyed		640
Sec. 36, T. 3 N., R. 24 E., S. B.	Unsurveyed		640
Sec 16, T. 4 N., R. 24 E., S. B.	Surveyed		480
Sec. 36, T. 4 N., R. 24 E., S. B.	Surveyed		560
Sec. 16, T. 5 N., R 24 E., S. B.	Surveyed		640
Sec. 16, T. 6 N., R. 24 E., S. B.	Surveyed		160
Sec. 16, T. 7 N., R. 24 E., S. B.	Surveyed		370.55
Sec. 16, T. 2 N., R. 25 E., S. B.	Unsurveyed		441.94
Sec 16, T. 3 N., R. 25 E., S. B.	Surveyed		640
Sec. 36, T. 3 N., R. 25 E., S. B.	Surveyed		640
Sec. 16, T. 4 N., R. 25 E., S. B.	Surveyed		241.80
Sec. 36, T. 4 N., R. 25 E., S. B.	Surveyed		640
Sec. 16, T. 5 N., R. 25 E., S. B.	Unsurveyed		640
Sec. 36, T. 5 N., R. 25 E., S. B.	Unsurveyed		160
Sec. 16, T. 2 N., R. 27 E., S. B.	Unsurveyed		640
Sec. 36, T. 2 N., R. 27 E., S. B.	Unsurveyed		251.60
Sec. 16, T. 3 N., R. 27 E., S. B.	Surveyed		320
Sec. 36, T. 3 N., R. 27 E., S. B.	Surveyed		320
Sec. 16, T. 6 N., R. 1 W., S. B.	Surveyed		160
Sec. 36, T. 7 N., R. 1 W., S. B.	Surveyed		640
Sec. 16, T. 8 N., R. 1 W., S. B.	Surveyed		320

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
36, T. 12 N., R. 1 W., S. B.	Unsurveyed		640	640
16, T. 2 N., R. 2 W., S. B.	Surveyed	366.25		366.25
36, T. 3 N., R. 2 W., S. B.	Unsurveyed	8.21		8.21
36, T. 4 N., R. 2 W., S. B.	Surveyed		640	640
16, T. 5 N., R. 2 W., S. B.	Surveyed		640	640
36, T. 5 N., R. 2 W., S. B.	Surveyed		640	640
16, T. 6 N., R. 2 W., S. B.	Surveyed		640	640
36, T. 6 N., R. 2 W., S. B.	Surveyed		640	640
16, T. 7 N., R. 2 W., S. B.	Surveyed		640	640
36, T. 7 N., R. 2 W., S. B.	Surveyed		640	640
36, T. 12 N., R. 2 W., S. B.	Unsurveyed		640	640
16, T. 3 N., R. 3 W., S. B.	Surveyed	7.36		7.36
36, T. 4 N., R. 3 W., S. B.	Surveyed		640	640
36, T. 6 N., R. 3 W., S. B.	Surveyed		640	640
36, T. 7 N., R. 3 W., S. B.	Surveyed		640	640
36, T. 12 N., R. 3 W., S. B.	Unsurveyed		640	640
16, T. 2 N., R. 4 W., S. B.	Surveyed	2.56		2.56
16, T. 3 N., R. 4 W., S. B.	Surveyed	9.95		9.95
16, T. 4 N., R. 4 W., S. B.	Surveyed		24.68	24.68
15, T. 6 N., R. 4 W., S. B.	Surveyed		640	640
36, T. 12 N., R. 4 W., S. B.	Unsurveyed		640	640
36, T. 4 N., R. 5 W., S. B.	Surveyed	160		160
36, T. 8 N., R. 5 W., S. B.	Surveyed		160	160
16, T. 12 N., R. 5 W., S. B.	Unsurveyed		640	640
36, T. 12 N., R. 5 W., S. B.	Unsurveyed		640	640
16, T. 3 N., R. 6 W., S. B.	Surveyed	.03		.03
36, T. 4 N., R. 6 W., S. B.	Surveyed	160		160
36, T. 9 N., R. 6 W., S. B.	Surveyed		80	80
16, T. 12 N., R. 6 W., S. B.	Unsurveyed		640	640
36, T. 12 N., R. 6 W., S. B.	Unsurveyed		640	640
36, T. 3 N., R. 7 W., S. B.	Surveyed	483.80		483.80
16, T. 7 N., R. 7 W., S. B.	Surveyed		80	80
36, T. 7 N., R. 7 W., S. B.	Surveyed		280	280
16, T. 4 N., R. 8 W., S. B.	Surveyed		640	640
16, T. 8 N., R. 8 W., S. B.	Surveyed		160	160
36, T. 2 N., R. 9 W., S. B.	Surveyed	46.30		46.30
36, T. 12 N., R. 9 W., S. B.	Surveyed		560.64	560.64
16, T. 1 N., R. 10 W., S. B.	Surveyed	640		640
36, T. 3 N., R. 10 W., S. B.	Surveyed	4.16		4.16
16, T. 4 N., R. 10 W., S. B.	Surveyed	14.22		14.22
16, T. 4 N., R. 11 W., S. B.	Unsurveyed	.15		.15
36, T. 9 N., R. 12 W., S. B.	Surveyed		40	40
16, T. 10 N., R. 13 W., S. B.	Surveyed		320	320
36, T. 10 N., R. 13 W., S. B.	Surveyed		480	480
36, T. 4 N., R. 15 W., S. B.	Surveyed	246		246
16, T. 7 N., R. 15 W., S. B.	Surveyed	21.94		21.94
16, T. 9 N., R. 15 W., S. B.	Surveyed		320	320
16, T. 6 N., R. 16 W., S. B.	Unsurveyed	301.15		301.15
16, T. 11 N., R. 16 W., S. B.	Surveyed		520	520
36, T. 11 N., R. 16 W., S. B.	Surveyed		200	200
36, T. 3 N., R. 17 W., S. B.	Surveyed		160	160
16, T. 6 N., R. 17 W., S. B.	Surveyed	140.41		140.41
36, T 7 N., R. 17 W., S. B.	Surveyed	3.67		3.67
36, T. 4 N., R. 19 W., S. B.	Surveyed		80	80
16, T. 4 N., R. 20 W., S. B.	Surveyed	19.14		19.14
36, T. 6 N., R. 25 W., S. B.	Surveyed	45.20		45.20
36, T. 10 N., R. 25 W., S. B.	Surveyed	640		640
16, T. 5 N., R. 28 W., S. B.	Surveyed	28.40		28.40
36, T. 12 N., R. 28 W., S. B.	Surveyed	11.46		11.46
16, T. 10 N., R. 31 W., S. B.	Surveyed	4.64		4.64

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	To be to 1 Apr
Sec. 36, T. 12 N., R. 31 W., S. B.	Surveyed		258.76	
Sec. 36, T. 10 N., R. 32 W., S. B.	Surveyed		75.57	
Sec. 16, T. 1 S., R. 1 W., S. B.	Surveyed	5.64		
Sec. 16, T. 2 S., R. 1 W., S. B.	Surveyed	322.06		
Sec. 36, T. 5 S., R. 1 W., S. B.	Surveyed		640	
Sec. 16, T. 6 S., R. 1 W., S. B.	Surveyed		240	
Sec. 36, T. 6 S., R. 1 W., S. B.	Surveyed		320	
Sec. 16, T. 9 S., R. 1 W., S. B.	Surveyed	640		
Sec. 36, T. 9 S., R. 1 W., S. B.	Surveyed	640		
Sec. 16, T. 11 S., R. 1 W., S. B.	Surveyed		210.71	
Sec. 16, T. 12 S., R. 1 W., S. B.	Surveyed	40.55		
Sec. 16, T. 13 S., R. 1 W., S. B.	Surveyed	560		
Sec. 16, T. 14 S., R. 1 W., S. B.	Surveyed		560	
Sec. 36, T. 14 S., R. 1 W., S. B.	Surveyed		441.95	
Sec. 16, T. 3 S., R. 2 W., S. B.	Surveyed		40	
Sec. 36, T. 4 S., R. 2 W., S. B.	Surveyed		212.72	
Sec. 16, T. 5 S., R. 2 W., S. B.	Surveyed		320	
Sec. 36, T. 5 S., R. 2 W., S. B.	Surveyed		372.60	
Sec. 36, T. 8 S., R. 2 W., S. B.	Surveyed		40	
Sec. 16, T. 9 S., R. 2 W., S. B.	Surveyed		640	
Sec. 36, T. 9 S., R. 2 W., S. B.	Surveyed		360	
Sec. 36, T. 10 S., R. 2 W., S. B.	Surveyed		320	
Sec. 36, T. 4 S., R. 3 W., S. B.	Surveyed		1.30	
Sec. 36, T. 6 S., R. 3 W., S. B.	Surveyed	40		
Sec. 36, T. 8 S., R. 3 W., S. B.	Surveyed		520	
Sec. 16, T. 4 S., R. 4 W., S. B.	Surveyed		160	
Sec. 16, T. 12 S., R. 4 W., S. B.	Surveyed		1.83	
Sec. 16, T. 5 S., R. 5 W., S. B.	Surveyed		160	
Sec. 16, T. 6 S., R. 5 W., S. B.	Surveyed		640	
Sec. 36, T. 6 S., R. 5 W., S. B.	Surveyed		160	
Sec. 36, T. 7 S., R. 8 W., S. B.	Surveyed		115.16	
Sec. 16, T. 1 S., R. 1 E., S. B.	Surveyed	.05		
Sec. 16, T. 4 S., R. 1 E., S. B.	Surveyed	.01		
Sec. 16, T. 7 S., R. 1 E., S. B.	Surveyed	320		
Sec. 36, T. 7 S., R. 1 E., S. B.	Surveyed	160		
Sec. 36, T. 9 S., R. 1 E., S. B.	Surveyed	320		
Sec. 36, T. 14 S., R. 1 E., S. B.	Surveyed	640		
Sec. 36, T. 15 S., R. 1 E., S. B.	Surveyed	80		
Sec. 36, T. 16 S., R. 1 E., S. B.	Surveyed	440		
Sec. 16, T. 17 S., R. 1 E., S. B.	Surveyed	160		
Sec. 16, T. 18 S., R. 1 E., S. B.	Surveyed	288.29		
Sec. 36, T. 18 S., R. 1 E., S. B.	Surveyed	241.91		
Sec. 36, T. 19 S., R. 1 E., S. B.	Surveyed	47.74		
Sec. 16, T. 7 S., R. 2 E., S. B.	Surveyed	1.03		
Sec. 16, T. 13 S., R. 2 E., S. B.	Surveyed	280		
Sec. 16, T. 15 S., R. 2 E., S. B.	Surveyed	320		
Sec. 36, T. 15 S., R. 2 E., S. B.	Surveyed		40	
Sec. 16, T. 2 S., R. 3 E., S. B.	Surveyed	5.17		
Sec. 16, T. 5 S., R. 3 E., S. B.	Surveyed	.06		
Sec. 16, T. 7 S., R. 3 E., S. B.	Surveyed	120		
Sec. 36, T. 15 S., R. 3 E., S. B.	Surveyed	40		
Sec. 16, T. 16 S., R. 3 E., S. B.	Surveyed	320		
Sec. 16, T. 17 S., R. 3 E., S. B.	Surveyed	480		
Sec. 36, T. 4 S., R. 4 E., S. B.	Surveyed	108.63		
Sec. 36, T. 6 S., R. 4 E., S. B.	Unsurveyed	40		
Sec. 16, T. 8 S., R. 4 E., S. B.	Unsurveyed	2.48		
Sec. 16, T. 12 S., R. 4 E., S. B.	Surveyed	40		
Sec. 16, T. 13 S., R. 4 E., S. B.	Surveyed	80		
Sec. 36, T. 16 S., R. 4 E., S. B.	Surveyed	640		
Sec. 16, T. 1 S., R. 5 E., S. B.	Surveyed		640	

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
1 S., R. 5 E., S. B.	Surveyed		.18	.18
2 S., R. 5 E., S. B.	Surveyed		320	320
2 S., R. 5 E., S. B.	Surveyed		600	600
3 S., R. 5 E., S. B.	Surveyed		640	640
6 S., R. 5 E., S. B.	Surveyed	39.08		39.08
7 S., R. 5 E., S. B.	Unsurveyed	.98		.98
9 S., R. 5 E., S. B.	Surveyed	40		40
11 S., R. 5 E., S. B.	Surveyed	640		640
11 S., R. 5 E., S. B.	Surveyed	640		640
12 S., R. 5 E., S. B.	Surveyed	600		600
12 S., R. 5 E., S. B.	Surveyed	640		640
13 S., R. 5 E., S. B.	Surveyed	640		640
13 S., R. 5 E., S. B.	Surveyed	640		640
14 S., R. 5 E., S. B.	Surveyed	640		640
14 S., R. 5 E., S. B.	Surveyed	640		640
15 S., R. 5 E., S. B.	Surveyed	360		360
15 S., R. 5 E., S. B.	Surveyed	320		320
16 S., R. 5 E., S. B.	Surveyed	640		640
16 S., R. 5 E., S. B.	Surveyed	640		640
17 S., R. 5 E., S. B.	Surveyed	640		640
18 S., R. 5 E., S. B.	Surveyed	240		240
1 S., R. 6 E., S. B.	Surveyed	320.14		320.14
1 S., R. 6 E., S. B.	Surveyed		640	640
2 S., R. 6 E., S. B.	Surveyed		640	640
2 S., R. 6 E., S. B.	Surveyed		640	640
3 S., R. 6 E., S. B.	Unsurveyed		640	640
3 S., R. 6 E., S. B.	Unsurveyed		640	640
5 S., R. 6 E., S. B.	Surveyed		640	640
6 S., R. 6 E., S. B.	Surveyed	15.68		15.68
7 S., R. 6 E., S. B.	Surveyed	.54		.54
9 S., R. 6 E., S. B.	Surveyed		480	480
12 S., R. 6 E., S. B.	Surveyed		640	640
12 S., R. 6 E., S. B.	Surveyed		640	640
13 S., R. 6 E., S. B.	Surveyed		640	640
13 S., R. 6 E., S. B.	Surveyed		640	640
14 S., R. 6 E., S. B.	Surveyed		640	640
15 S., R. 6 E., S. B.	Surveyed	640		640
15 S., R. 6 E., S. B.	Surveyed	640		640
16 S., R. 6 E., S. B.	Surveyed	640		640
16 S., R. 6 E., S. B.	Surveyed	600		600
17 S., R. 6 E., S. B.	Surveyed	640		640
18 S., R. 6 E., S. B.	Surveyed	606.07		606.07
1 S., R. 7 E., S. B.	Unsurveyed		640	640
1 S., R. 7 E., S. B.	Unsurveyed		640	640
2 S., R. 7 E., S. B.	Unsurveyed		640	640
2 S., R. 7 E., S. B.	Unsurveyed		640	640
3 S., R. 7 E., S. B.	Unsurveyed		640	640
3 S., R. 7 E., S. B.	Unsurveyed		640	640
4 S., R. 7 E., S. B.	Surveyed		640	640
7 S., R. 7 E., S. B.	Surveyed	62.95		62.95
8 S., R. 7 E., S. B.	Surveyed	1.09		1.09
8 S., R. 7 E., S. B.	Surveyed	2.64		2.64
9 S., R. 7 E., S. B.	Surveyed		640	640
10 S., R. 7 E., S. B.	Surveyed		640	640
12 S., R. 7 E., S. B.	Surveyed		640	640
13 S., R. 7 E., S. B.	Surveyed		640	640
13 S., R. 7 E., S. B.	Surveyed		640	640
14 S., R. 7 E., S. B.	Surveyed		640	640
14 S., R. 7 E., S. B.	Surveyed		640	640
15 S., R. 7 E., S. B.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outsi Nationa Forest Reserve.
Sec. 16, T. 17 S., R. 7 E., S. B.	Surveyed		240
Sec. 36, T. 17 S., R. 7 E., S. B.	Surveyed		640
Sec. 16, T. 1 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 1 S., R. 8 E., S. B.	Surveyed		320
Sec. 16, T. 2 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 2 S., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 3 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 3 S., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 4 S., R. 8 E., S. B.	Unsurveyed		640
Sec. 36, T. 4 S., R. 8 E., S. B.	Unsurveyed		640
Sec. 16, T. 5 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 5 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 12 S., R. 8 E., S. B.	Surveyed		200.
Sec. 16, T. 13 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 13 S., R. 8 E., S. B.	Surveyed		495.
Sec. 16, T. 14 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 14 S., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 15 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 15 S., R. 8 E., S. B.	Surveyed		640
Sec. 36, T. 16 S., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 17 S., R. 8 E., S. B.	Surveyed		640
Sec. 16, T. 1 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 1 S., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 2 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 2 S., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 3 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 3 S., R. 9 E., S. B.	Surveyed		640
Sec 16, T. 4 S., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 5 S., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 5 S., R. 9 E., S. B.	Unsurveyed		640
Sec. 36, T. 5 S., R. 9 E., S. B.	Unsurveyed		640
Sec. 16, T. 6 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 6 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 8 S., R. 9 E., S. B.	Surveyed		1.
Sec. 16, T. 11 S., R. 9 E., S. B.	Surveyed		320
Sec. 36, T. 13 S., R. 9 E., S. B.	Surveyed		640
Sec. 36, T. 14 S., R. 9 E., S. B.	Surveyed		321.
Sec. 36, T. 15 S., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 17 S., R. 9 E., S. B.	Surveyed		640
Sec. 16, T. 1 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 36, T. 1 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 16, T. 2 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 36, T. 2 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 16, T. 3 S., R. 10 E., S. B.	Surveyed		640
Sec. 36, T. 3 S., R. 10 E., S. B.	Surveyed		640
Sec. 16, T. 4 S., R. 10 E., S. B.	Unsurveyed		640
Sec 36, T. 4 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 16, T. 5 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 36, T. 5 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 16, T. 6 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 36, T. 6 S., R. 10 E., S. B.	Unsurveyed		640
Sec. 36, T. 15 S., R. 10 E., S. B.	Surveyed		80
Sec 16, T. 16 S., R. 10 E., S. B.	Surveyed		
Sec 16, T. 17 S., R. 10 E., S. B.	Surveyed		640
Sec. 16, T. 1 S., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 1 S., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 2 S., R. 11 E., S. B.	Unsurveyed		640
Sec. 36, T. 2 S., R. 11 E., S. B.	Unsurveyed		640
Sec. 16, T. 3 S., R. 11 E., S. B.	Surveyed		640
Sec. 36, T. 3 S., R. 11 E., S. B.	Surveyed		640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Unsurveyed		640	640
R. 11 E., S. B.	Surveyed		320	320
R. 11 E., S. B.	Surveyed		80	80
R. 11 E., S. B.	Surveyed		480	480
R. 11 E., S. B.	Surveyed		292.86	292.86
R. 11 E., S. B.	Surveyed		640	640
R. 11 E., S. B.	Surveyed		.99	.99
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		619.34	619.34
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S B.	Surveyed		640	640
R. 12 E., S. B.	Unsurveyed		640	640
R. 12 E., S. B.	Unsurveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Unsurveyed		640	640
R. 12 E., S. B.	Unsurveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 12 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Surveyed		640	640
R. 13 E., S. B.	Unsurveyed		640	640
R. 13 E., S. B.	Unsurveyed		600	600
R. 13 E., S. B.	Surveyed		281.13	281.13
R. 14 E., S. B.	Surveyed		160	160
R. 14 E., S. B.	Surveyed		160	160
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Unsurveyed		640	640
R. 14 E., S. B.	Unsurveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Unsurveyed		640	640
R. 14 E., S. B.	Unsurveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 14 E., S. B.	Surveyed		640	640
R. 15 E., S. B.	Surveyed		640	640
R. 15 E., S. B.	Surveyed		640	640

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outsi National Forest Reserve.
Sec. 16, T. 2 S., R. 15 E., S. B.	Surveyed		640
Sec. 36, T. 2 S., R. 15 E., S. B.	Surveyed		640
Sec. 16, T. 3 S., R. 15 E., S. B.	Surveyed		320
Sec. 16, T. 4 S., R. 15 E., S. B.	Surveyed		320
Sec. 36, T. 5 S., R. 15 E., S. B.	Surveyed		480
Sec. 16, T. 6 S., R. 15 E., S. B.	Unsurveyed		640
Sec. 36, T. 6 S., R. 15 E, S. B.	Unsurveyed		640
Sec. 16, T. 7 S., R. 15 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 S., R. 15 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 S., R. 15 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 S., R. 15 E., S. B.	Unsurveyed		640
Sec. 16, T. 9 S., R. 15 E., S. B.	Surveyed		640
Sec. 36, T. 9 S., R. 15 E., S. B.	Surveyed		640
Sec 36, T. 10 S., R. 15 E., S. B.	Surveyed		640
Sec. 36, T. 11 S., R. 15 E., S. B.	Surveyed		320
Sec. 16, T. 2 S., R. 16 E., S. B.	Surveyed		480
Sec. 16, T. 3 S., R. 16 E., S. B.	Surveyed		320
Sec. 36, T. 3 S., R. 16 E., S. B.	Surveyed		640
Sec. 16, T. 4 S., R. 16 E., S. B.	Surveyed		480
Sec. 36, T. 4 S., R. 16 E., S. B.	Surveyed		289.
Sec 16, T. 6 S., R. 16 E., S. B.	Surveyed		640
Sec. 36, T. 6 S., R. 16 E., S. B.	Surveyed		640
Sec. 16, T. 7 S., R. 16 E., S. B.	Unsurveyed		640
Sec. 36, T. 7 S., R 16 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 S., R. 16 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 S., R. 16 E, S. B.	Unsurveyed		640
Sec. 16, T. 9 S., R. 16 E., S. B.	Unsurveyed		640
Sec 36, T. 9 S., R. 16 E., S. B.	Unsurveyed		640
Sec. 16, T. 10 S., R. 16 E., S. B.	Unsurveyed		640
Sec. 36, T. 10 S., R. 16 E., S. B.	Unsurveyed		640
Sec. 16, T. 13 S., R. 16 E., S. B.	Surveyed		320
Sec. 16, T. 1 S., R. 17 E., S. B.	Surveyed		640
Sec. 36, T. 1 S., R. 17 E., S. B.	Surveyed		320
Sec. 16, T. 2 S., R. 17 E., S. B.	Surveyed		160
Sec. 36, T. 4 S., R. 17 E., S. B.	Surveyed		480
Sec. 16, T. 7 S., R. 17 E., S. B.	Unsurveyed		640
Sec 36, T. 7 S., R. 17 E., S. B.	Unsurveyed		640
Sec. 16, T. 8 S., R. 17 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 S., R. 17 E., S. B.	Unsurveyed		640
Sec. 16, T. 9 S., R. 17 E., S. B.	Surveyed		640
Sec. 36, T. 9 S., R. 17 E., S. B.	Surveyed		640
Sec. 16, T. 10 S., R. 17 E., S. B.	Surveyed		640
Sec. 36, T. 10 S., R. 17 E., S. B.	Surveyed		640
Sec. 16, T. 11 S., R. 17 E., S. B.	Surveyed		640
Sec. 36, T. 11 S., R. 17 E., S. B.	Surveyed		640
Sec. 16, T. 17 S., R. 17 E., S. B.	Surveyed		8.
Sec. 16, T. 2 S., R. 18 E., S. B.	Surveyed		640
Sec 36, T. 2 S., R. 18 E., S. B.	Surveyed		320
Sec. 36, T. 3 S., R. 18 E., S. B.	Surveyed		640
Sec. 16, T. 4 S., R. 18 E., S. B.	Surveyed		640
Sec. 36, T. 4 S., R. 18 E., S. B.	Surveyed		640
Sec 16, T. 5 S., R. 18 E., S. B.	Surveyed		640
Sec. 16, T. 8 S., R. 18 E., S. B.	Unsurveyed		640
Sec. 36, T. 8 S., R. 18 E., S. B.	Unsurveyed		640
Sec. 16, T. 9 S., R. 18 E., S. B.	Surveyed		640
Sec. 16 T. 10 S., R. 18 E., S. B.	Surveyed		480
Sec. 36, T. 10 S., R. 18 E., S. B.	Surveyed		640
Sec 16, T. 11 S., R. 18 E., S. B.	Surveyed		640
Sec 36, T. 11 S., R. 18 E., S. B.	Surveyed		640
Sec 16, T. 12 S., R. 18 E., S. B.	Surveyed		320

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
14 S., R. 18 E., S. B.	Surveyed		640	640
14 S., R. 18 E., S. B.	Surveyed		320	320
15 S., R. 18 E., S. B.	Surveyed		640	640
3 S., R. 19 E., S. B.	Surveyed		320	320
4 S., R. 19 E., S. B.	Surveyed		160	160
5 S., R. 19 E., S. B.	Unsurveyed		640	640
5 S., R. 19 E., S. B.	Unsurveyed		640	640
7 S., R. 19 E., S. B.	Surveyed		320	320
8 S., R. 19 E., S. B.	Unsurveyed		640	640
8 S., R. 19 E., S. B.	Unsurveyed		640	640
11 S., R. 19 E., S. B.	Surveyed		640	640
12 S., R. 19 E., S. B.	Unsurveyed		640	640
13 S., R. 19 E., S. B.	Surveyed		640	640
15 S., R. 19 E., S. B.	Surveyed		640	640
17 S., R. 19 E., S. B.	Unsurveyed		320	320
3 S., R. 20 E., S. B.	Surveyed		640	640
3 S., R. 20 E., S. B.	Surveyed		640	640
5 S., R. 20 E., S. B.	Unsurveyed		640	640
5 S., R. 20 E., S. B.	Unsurveyed		640	640
8 S., R. 20 E., S. B.	Unsurveyed		640	640
8 S., R. 20 E., S. B.	Unsurveyed		640	640
9 S., R. 20 E., S. B.	Unsurveyed		640	640
9 S., R. 20 E., S. B.	Unsurveyed		640	640
10 S., R. 20 E., S. B.	Surveyed		640	640
11 S., R. 20 E., S. B.	Surveyed		640	640
11 S., R. 20 E., S. B.	Surveyed		640	640
12 S., R. 20 E., S. B.	Surveyed		640	640
12 S., R. 20 E., S. B.	Surveyed		640	640
13 S., R. 20 E., S. B.	Surveyed		640	640
13 S., R. 20 E, S. B.	Surveyed		640	640
14 S., R. 20 E., S. B.	Surveyed		640	640
15 S., R. 20 E., S. B.	Surveyed		640	640
15 S., R. 20 E., S. B.	Surveyed		320	320
16 S., R. 20 E., S. B.	Surveyed		560	560
16 S., R. 20 E., S. B.	Surveyed		640	640
3 S., R. 21 E., S. B.	Surveyed		640	640
4 S., R. 21 E., S. B.	Surveyed		320	320
6 S., R. 21 E., S. B.	Surveyed		640	640
7 S., R. 21 E., S. B.	Surveyed		640	640
12 S., R. 21 E., S. B.	Surveyed		640	640
13 S., R. 21 E., S. B.	Unsurveyed		640	640
13 S., R. 21 E., S. B.	Unsurveyed		640	640
14 S., R. 21 E., S. B.	Surveyed		640	640
14 S., R. 21 E., S. B.	Surveyed		640	640
15 S., R. 21 E., S. B.	Surveyed		520	520
15 S., R. 21 E., S. B.	Surveyed		160	160
1 S., R. 22 E., S. B.	Surveyed		480	480
1 S., R. 22 E., S. B.	Surveyed		160	160
3 S., R. 22 E., S. B.	Surveyed		640	640
3 S., R. 22 E., S. B.	Surveyed		640	640
4 S., R. 22 E., S. B.	Unsurveyed		640	640
4 S., R. 22 E., S. B.	Unsurveyed		640	640
13 S., R. 22 E., S. B.	Surveyed		483.42	483.42
14 S., R. 22 E., S. B.	Surveyed		640	640
14 S., R. 22 E., S. B.	Surveyed		360	360
15 S., R. 22 E., S. B.	Surveyed		640	640
16 S., R. 22 E., S. B.	Surveyed		80	80
1 S., R. 23 E., S. B.	Surveyed		640	640
2 S., R. 23 E., S. B.	Surveyed		279.90	279.90
3 S., R. 23 E., S. B.	Surveyed		480	480

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EXHIBIT D—*Continued.*

	Surveyed or unsurveyed.	Area within National Forest Reserve.	Area outside National Forest Reserve.	Total area belonging to the State April 1, 1912.
Sec. 16, T. 4 S., R. 23 E., S. B.	Surveyed		320	320
Sec. 16, T. 5 S., R. 25 E., S. B.	Surveyed		640	640
Sec. 16, T. 6 S., R. 23 E., S. B.	Surveyed		560	560
Sec. 36, T. 13 S., R. 23 E., S. B.	Surveyed		160	160
Sec. 16, T. 14 S., R. 23 E., S. B.	Surveyed		640	640
Sec. 16, T. 15 S., R. 23 E., S. B.	Surveyed		640	640
Sec 16, T. 16 S., R. 23 E., S. B.	Surveyed		230.28	230.28
Sec. 16, T. 1 S., R. 24 E., S. B.	Unsurveyed		640	640
Sec. 16, T. 2 S., R. 24 E., S. B.	Unsurveyed		13.64	13.64
Sec. 16, T. 14 S., R. 24 E., S. B.	Surveyed		9.90	9.90

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EXHIBIT E.

ate Conservation Commission,
ilding, San Francisco, Cal.

BERKELEY, CAL., March 7, 1912.

ubmit herewith, in accordance with your request, a brief statement with the dredged land situation in this State and its effect on the amount agricultural lands of California. Before making such statements as rtinent on the basis of my visit to the dredged districts of Oroville and sh to submit some statistical information which may tend to make my nore definite significance. I am indebted for these statistics to Mr. who included them in his report to the Section on Conservation of the h Club on the subject of minerals in California.

) to 1911 the amount of gold produced by the world through dredging rease from 1 per cent to 1.65 per cent, taking 100 per cent as the total he world. The following table further gives an idea of the dredging various counties of California available for such purposes:

Counties.	Total proven dredging ground.	Total acreage owned by dredging companies.
	6,600	8,900
	3,600	5,500
	430	990
	6,050	12,500
	850	850
	200	1,000
	400	500
	700	2,000
	370	450
	19,200	32,690

ment appended to these figures shows that probably less than 5,000 acres been dredged. I shall refer to this matter later. Then as to the old produced through dredging as compared with that produced from in California, we find the following statistics:

Source.	1898.	1909.
	$12,488,321	$11,133,437
s	1,028,547	739,797
acers	1,841,473	376,078
	19,000	7,382,950
	962,192	605,608

well to add to these figures a table showing the rapid increase in ry year since 1898.

	$18,847
	133,812
	200,369
	471,934
	801,295
	1,488,556
	2,187,038
	3,276,141
	5,098,359
	5,065,437
	6,536,089
	7,382,950

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LOCALITIES AND AREAS OF PRESENT DREDGING OPERATIONS.

The largest dredging areas in California to-day are undoubtedly in the Orovil and Folsom districts and along the Yuba River. The acreage dredged, in accordan with statements of people on the spot, who should have authoritative informatio would seem to be much larger than that reported in the figures above noted. Th is to say, Mr. Leggett, at Oroville, told the writer that in his opinion, more th 5,000 acres had already been dredged at Oroville alone and that 2,000 acres mo would probably be dredged in that district. That does not take into considerati a very considerable area at Folsom and on the Yuba River. It suffices for o purposes here to know that, while 7,000 acres may be the total for the Orovil district, the lands now being dredged by the Natomas Consolidated, at Folsom a vicinity, will no doubt show an increase in acreage year by year. Mr. Leggett also authority for the statement that the largest amount of dredging will be do along the Yuba River. In other words, we are facing a condition where dredgi is to be carried out, not merely on a limited area, but in several different parts the State, and will undoubtedly increase, as gravelly lands, by assay, have sho them worthy of being dredged for gold.

THE KIND OF LAND BEING DREDGED.

I think it is safe to say that the largest part of the land dredged at Oroville w from the agricultural standpoint, of little value. It is Mr. Leggett's opinion th only 10 per cent of the land that has been thus far dredged in the Oroville distri was at all fit for agricultural purposes. In the Folsom district it is estimated th approximately 20 per cent of the land thus far dredged was fit for agricultu purposes, while, as regards the Yuba River district, it is hard to give an estim of the amount of land actually fit for agriculture, which is now being dredged or to be dredged in the future. In this connection it should be remembered th considerable areas of land are being purchased by the various dredging compani in the Folsom district and along the Yuba River which are producing good cro and which are being made unfit to a greater or less degree, as will be later discuss by dredging.

THE RECLAMATION OF DREDGED LAND.

In connection with the subject of whether or not dredging of land should allowed, an eminently pertinent question arising is "Can dredged land be reclaim for agricultural purposes?" Before giving my own opinion in the matter, I m give an account of the observations I have made of the two attempts at the recla ation of dredged land; one at Oroville by Mr. Leggett, and the other at Natom near Folsom, by the Natomas Consolidated.

On a ten-acre lot, which has been leveled after dredging, Mr. Leggett planted large variety of fruits, among them vines, figs, apricots, peaches, oranges, olives a walnuts. The oranges and olives were old trees which had been cut back a moved to the new land from old orchards. The other fruits were planted fro young stock. For all plantings, top soil was put into every hole to start the pla on. The oranges and figs are, to judge from Mr. Leggett's experiment, a failu without doubt, while the others seemingly do fairly well, but, with the excepti of the vines, have attained only a small growth, though showing good blossomi and fairly good fruit production. It is hard to say now, since the walnuts a olives are both too recently planted to produce, whether or not they will produ sufficiently to make them profitable. Mr. Leggett has also planted, on adjace land to the oranges, eucalyptus trees now nearly seven years old without a leveling of the débris. It must be stated here that these eucalyptus trees are a looking fine and apparently vigorously and rapidly growing.

The attempt at reclaiming the dredged land near Natoma by the Natomas Co solidated has been more systematically and carefully carried out than Mr. Leggett work. They have very carefully leveled the land in terraces and have thus f planted 15 acres in eucalyptus trees about one third each of 1-year, 2-year, and 3-ye old trees. There are, at the present time, being prepared 15 acres more for olive

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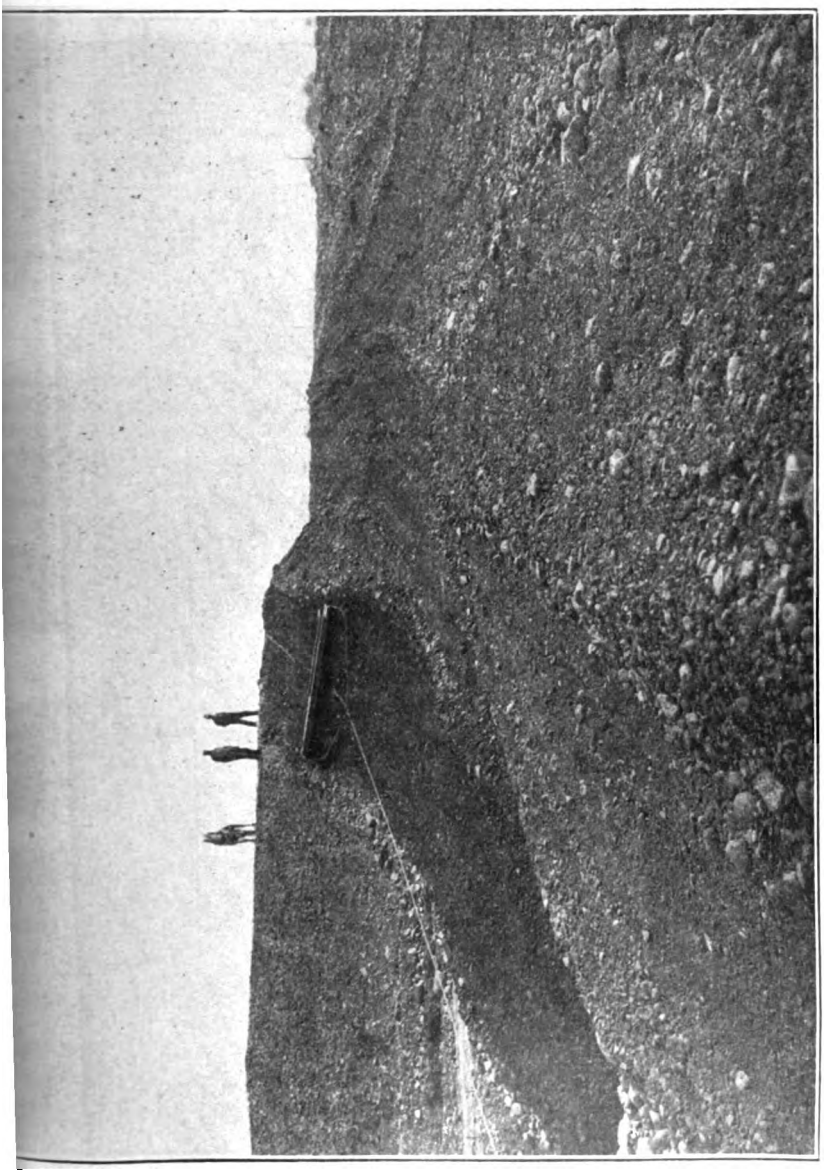

Reclaiming Dredged Lands.

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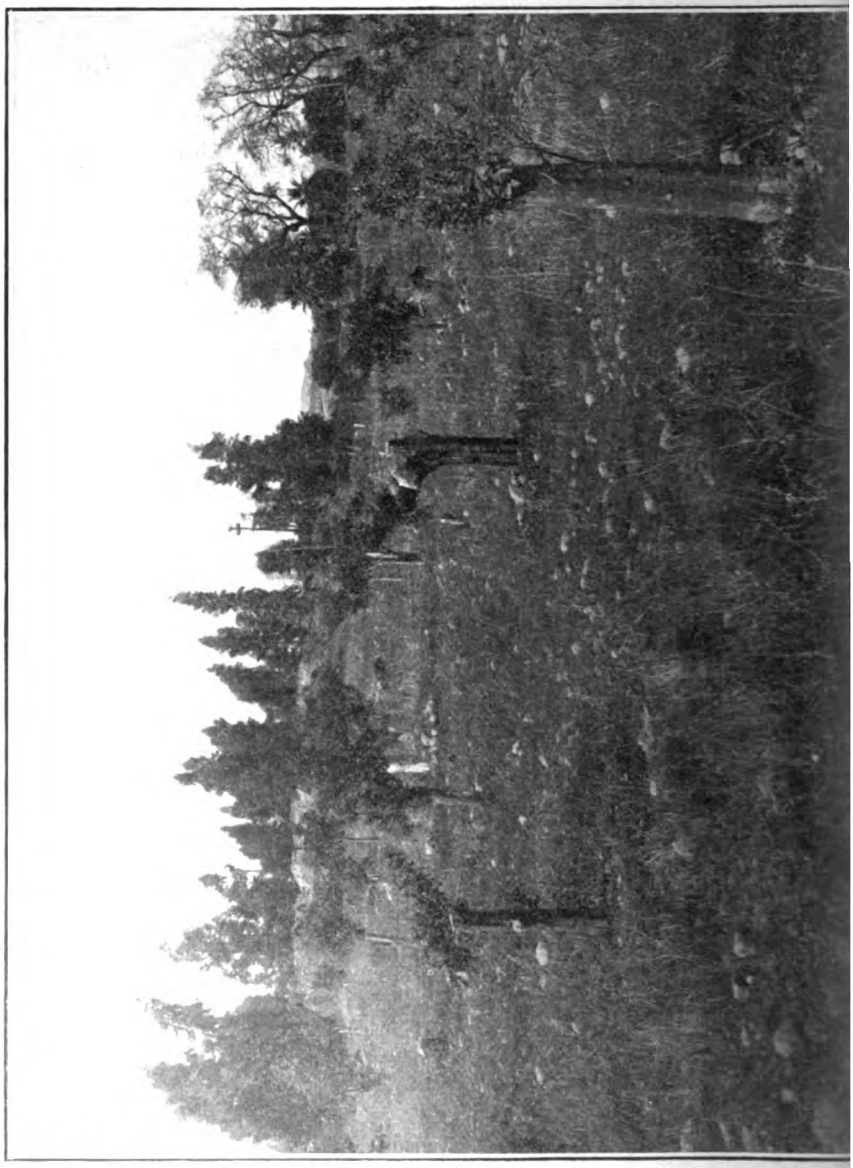

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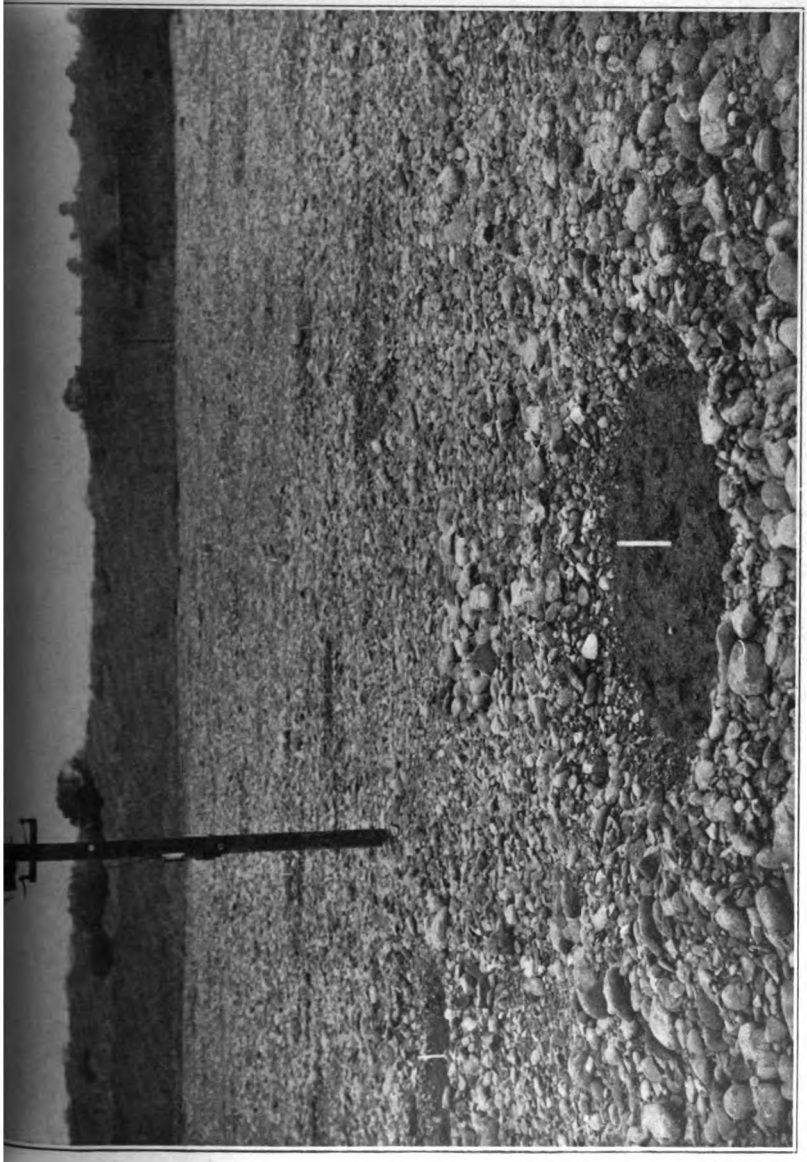

The young tree is started by good soil being placed in the hole excavated for it.

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which will be planted shortly. In each hole in which the tree was plan load of good top soil was placed to start the tree and it is report authentically or not, I cannot say) that the preparation of the land by the Natomas Consolidated involved an expenditure of $250 per acre. the condition of the eucalyptus trees described above, it must be stat are all doing well and evidently making a vigorous growth, not any, in far as I can see by an examination of them, showing any effects from food or water. It should be noted, however, that in both cases in wh was done on dredged land, top soil was placed into the holes for plan trees. Regardless of whether or not the figures above given for the per acre are authentic, the expenditure certainly must be large. In what I mean to bring out by this statement is that it is doubted if, in by private individuals, such dredged lands can be reclaimed and made to on the investment. I am inclined to the belief that that is impossible, experiments with fruit trees should yield larger profits per acre than can from eucalyptus.

Another point which must be brought out in this connection is that t all the dredged land is not the same, viz., there are portions of the dred which contain only small quantities of soil, whereas others contain lar of good soil. Hence, it is only reasonable to suppose that the latter m fair start, be a good medium for root development and hence for p whereas the former might be useless. This is a distinction between kinds of dredged soil which, in my opinion, cannot be overlooked in co value of dredged lands for agricultural purposes.

THE ESTHETIC POINT OF VIEW.

Outside of and in addition to all other considerations, I think th most practical minded will concede that the esthetic phases of the qu dredged land in California cannot be justly overlooked. While these only minor importance in connection with the hydraulic gravel beds of district and the remains of the placer mines there, they certainly are o moment in some of the other districts which have been mentioned abo senting the fields in which dredging activities are being carried out. the beautiful shores of the American River, along which are to be fo the most picturesque and pleasing views in the State, are in certain p converted into the desolate condition of a wide expanse of cobblest irregular height. The same is also true of other sections of the area dredged in the State. The citizens of California, and for that ma country, are not justified in allowing, without restraint or hindrance, ment of a large acreage of land, even though that land may ha financial value as compared with the total amount of wealth obtai dredging it. It is my point of view, however unjustified it may be, t that contributes to the natural beauties of this State should be as m to the shielding influence of conservation as these things which contr material wealth. I mention this here, because not only a considerabl country has already been disfigured by the dredging but because I a possibility of such large acreages in the future being similarly made des the same industry. The question naturally arises, "Where shall we s cess of desolation and can we stop a portion of it if the rest be allowe These questions must have definite answer from those who are lookin the future policy of the State in such matters.

GENERAL REMARKS.

Without assuming in any way the attitude of the extremist in matters and looking at this question of the dredged lands in Califor broadest possible point of view, including the agricultural, I cannot se come to any other conclusion than that dredging of land in this State, analysis, is, and must continue to be, a distinct detriment to the agric

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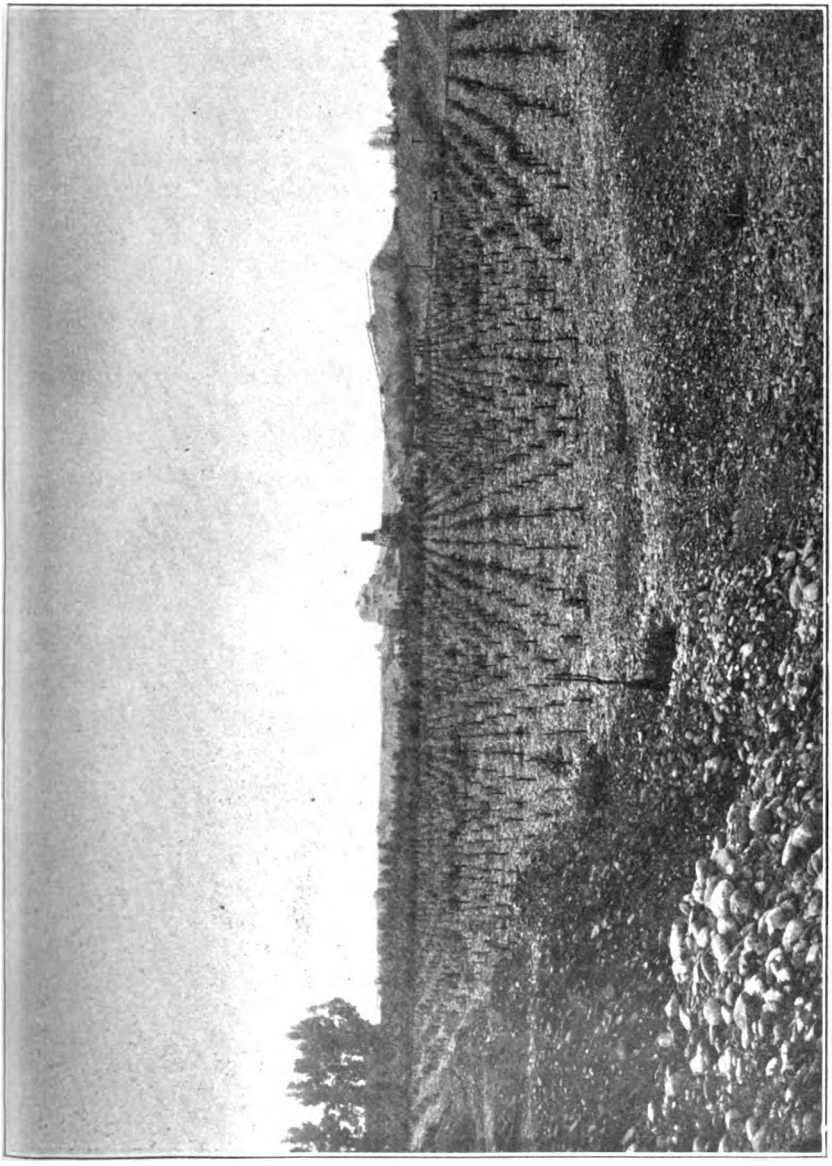

Young eucalyptus trees planted on lands of the Natomas Company.

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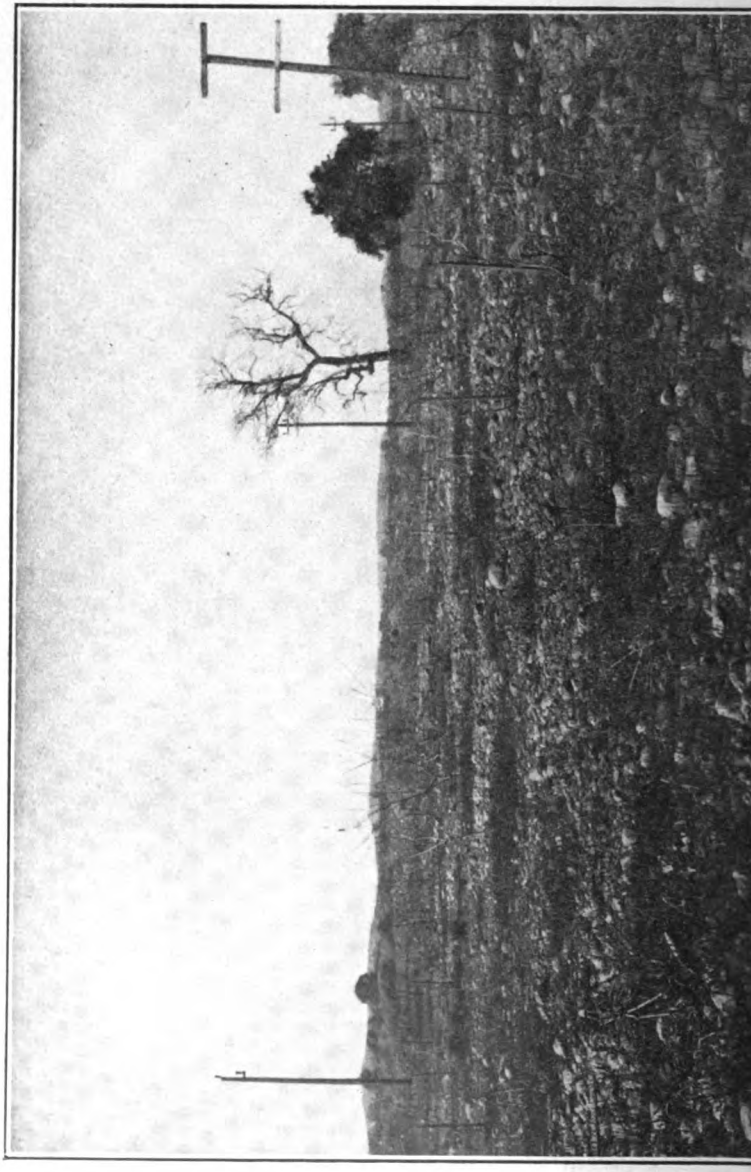

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State, to say nothing of the other phases of the question above considered; this, despite the fact that the full recognition is given to the various arguments put forth that the large amount of wealth obtained through dredging per acre may give larger returns than the same lands agriculturally managed may give to many generations of farmers. Further than that, it is impossible at the present time to say whether or not the reclamation of these dredged lands will be possible in such a manner as to make them sources of income to average farmers. While with the attitude of the scientific man, I cannot deny that the possibility, and even the probability, of this condition may exist, I cannot help but entertain some grave doubts with reference to the matter.

It is true that large acreages of land so far dredged have been agriculturally valueless and to that extent the dredging companies have not seriously injured the agriculture of California. It is true, moreover, that large acreages of the land thus far dredged were, prior to dredging, in such condition that the further operations of the dredger did not seriously change the appearance of the country. It is also true that an enormous amount of wealth is being annually taken out of the dredged lands which may represent, in some cases, far larger amounts of money than those lands will yield, agriculturally, in a century, or more, to come. It is true that some attempts are being made by the dredging companies to reclaim that land by planting to eucalyptus and olives.

Still, opposed to all these facts, it is likewise true that if an effort is not made to check the progress of the dredging companies, such large acreages as they will ultimately work are bound to include not only valueless land, but also very valuable land. It is also to be opposed to the second truthful claim of the dredging companies that, while in the past, large acreages of land turned up have not in any way damaged or disfigured the country, that at the present time, and still more largely in the future, large acreages turned up by the dredgers will greatly disfigure and render valueless and desolate some of the beautiful parts of our State. While it may be that the total amount of wealth obtained from each acre of dredged land may be far in excess of what many generations of farmers may take out on the same land, agriculturally worked, I cannot see how this generation has a right to rob the coming generations of lands which otherwise might be made in the future to support a very considerable population. Besides, the money which is obtained through dredging does not necessarily come into circulation and probably, usually, does not do so in such a manner as to constitute a permanent source of wealth for the inhabitants of the State. The capital obtained through dredging the lands, at the present time, remains largely centered in a few hands and will more than likely remain in the hands of a few; whereas, agricultural land will continue to be a source of income to a local population much larger in number than the few benefited by the dredging for a longer number of years, even if all other features are not considered. While the most valid objection to the campaign against dredging by the dredging companies may be that the dredged land can be reclaimed, the instances cited above with reference to such attempts at reclamation are not to my mind of value conclusive enough to make the matter practicable and assuredly profitable. In the absence of better evidence than we have on this subject, I think that we can safely consider the results thus far obtained on the reclamation of dredged lands as an argument in favor of the opposition to the dredging companies.

Accompanying my report, I am submitting a series of photographs taken by Mr. [illegible] Adams, who was with me on my visits to Oroville and Folsom, which show the conditions of the dredged lands and the efforts at reclamation being made. They will help to give an idea as to the appearance of the country in which the dredging operations are being carried on.

Respectfully submitted.

CHAS. B. LIPMAN.

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EXHIBIT F.

CALIFORNIA STATE BOARD OF FORESTRY, SACRAMENTO, May 15

Conservation Commission, 702 Mills Building, San Francisco, California

GENTLEMEN: I enclose for your information, the first installment collected on forest taxation in California. This is the first time that of this character has been assembled. Although the figures are estim are just as accurate as can be obtained without handling each tax recei several counties. It is impossible to get them exact at this time because is very expensive. The counties have never compiled this informati believe the figures to be pretty close and will serve as a guide in determi effect a proper tax on yield would have on the income of these counties chiefly upon revenue derived from timber taxation. It will be necessar as funds are available, to secure, in addition to the lowest and highes timber land and cut-over land, the percentage of the area assessed at t rates. This means again, the handling of each tax receipt which is a more piece of work than could be undertaken at present. These figures are su least, to show the need for some adjustment in the application of th method, that there may be a more uniform basis for assessment of simil land equally accessible or inaccessible.

There will be sent to you, as soon as it can be type-written, a summar other states are doing, showing briefly, existing laws; which states h studies of forest taxation, and those where studies are being contemplated with an alphabetical list of owners showing the assessed amount, by acres, land and cut-over land, by counties, and the total. Fire data is in the preparation and will be gotten out as soon as possible.

Yours very truly,

G. M. HOMA
State F

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County.	Assessed valuation per acre.				Tax rate per $100.	Estimate per cent of total amount of county tax derived from timber land.
	Timber land.		Cut-over land.			
	Lowest.	Highest.	Lowest.	Highest.		
Alpine	$3 00	$3 00	----------	----------	$2 00	
Amador	7 50	7 50	$2 50	$3 00	2 20	
Butte	2 50	10 00	1 25	2 50	2 30	
Calaveras	10 00	10 00	1 25	4 00	2 25	
Del Norte	20 00	67 50	3 00	5 00	1 75	75 to 80
El Dorado	10 00	10 00	2 00	2 00	2 00	
Fresno	8 00	12 50	1 50	1 50	1 64	
Glenn	2 00	10 00	2 00	2 00	1 82	5
Humboldt	2 00	60 00	4 00	6 00	1 90	40
Kern	1 33	1 33	2 00	12 00	1 20	
Lake	3 00	4 00	2 00	2 50	2 15	
Lassen	2 50	12 50	2 00	2 00	----------	25
Madera	10 00	10 00	1 50	1 50	2 30	
Marin	9 00	9 00	9 00	9 00	1 55	
Mariposa	12 50	25 00	3 50	3 50	1 70	25
Mendocino	10 00	10 00	2 50	2 50	2 14	50
Modoc	5 00	12 00	2 00	2 50	1 60	33
Mono	2 50	3 00	1 50	2 00	2 00	
Monterey	1 25	4 00	1 25	4 00	1 55	
Nevada	2 00	5 00	1 00	1 00	2 50	
Orange	41 00	41 00	----------	----------	1 50	
Placer	4 00	6 00	1 00	1 00	2 25	15
Plumas	8 00	12 00	2 00	2 00	----------	65
Riverside	2 18	2 18	----------	----------	2 00	
San Benito	----------	----------	1 50	1 50	1 70	
San Bernardino	2 25	7 50	2 00	3 00	2 50	
San Diego	1 50	1 50	----------	----------	2 00	
San Luis Obispo	1 25	1 25	----------	----------	2 11	
San Mateo	8 00	12 00	2 00	5 00	1 85	
Santa Cruz	10 00	50 00	5 00	8 00	2 10	
Shasta	5 00	10 00	50	2 00	2 24	25
Sierra	2 50	6 00	1 00	1 00	2 00	
Siskiyou	6 00	7 00	1 00	1 00	2 00	65
Sonoma	3 00	50 00	4 00	5 00	1 60	
Tehama	3 00	10 00	50	2 00	----------	
Trinity	5 00	10 00	1 00	1 00	2 60	50
Tulare	2 50	30 00	1 50	1 50	1 70	
Tuolumne*	10 00	80 00	2 00	2 00	1 95	
Yuba	5 00	5 00	2 00	2 00	2 40	

*Big tree tracts are assessed for $80.00, other timber land for $10.00.

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FOREST TAXATION BY COUNTIES.

Alameda County.

There is no timber land in Alameda County. The assessor that from 85 to 90 per cent of the total tax is received from inco cities. An actual examination of the land is made annu assessing orchard land, the fruit trees are not separated from The assessed value of lands ranges from $4.00 to $600.00 per ac assessor estimates that these assessed values represent 60 pe the actual value. There are no regular rules for assessing. is expected in assessed values this year. The tax rate in 1911 per $100.00 on land outside of the cities. There are no sa the county.

Alpine County.

There is only a small area of timber land in this county (6,03 In assessing, the trees are not separated from the land. No cr made. The assessed value of the timber land is $3.00 per acr the farm land $12.00 to $30.00 per acre. The tax rate in $2.00 per $100.00. No raise in values is expected. There is sawmill in the county. The largest proportion of the tot contributed by the farming land.

Amador County.

This county has considerable timber land. No cruises a and the work is not systematized. The trees are not separa the land. Timber land is assessed at $7.50 per acre, cut-ove $2.50 to $3.00 per acre, and grazing land at $2.00 to $3.00 The tax rate on land outside of cities was $2.20 per $100.00 The assessor estimates that the assessed value equals about 60 of the actual value. An increase in the assessed values was 1911. The assessor is in favor of having the timber cruised.

Butte County.

This county has considerable timber land. An actual exa of the greater part is made annually, and part of the land i by the deputy assessor. The timber land is divided into thre the first being assessed at $8.00 to $10.00 per acre, the second to $7.00 per acre, and the third at $2.50 to $6.00 per acre. land is assessed at $1.25 to $2.50 per acre. The tax rate in $2.30 per $100.00. The average actual value of the timber estimated to be about $24.00 per acre. There are no plans fo in this county and the people are well satisfied with the method of taxation.

Calaveras County.

There is considerable timber land in this county. The tree separated from the land, and no cruises are made. There is s of hiring a cruiser, but the county is afraid of the cost. The

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was $2.05 per $100.00 in 1911. The assessed value of timber land is $10.00 per acre, of cut-over land $1.25 to $4.00 per acre, and chaparral land $2.50 to $5.00 per acre. The actual values are represented at $8.00 to $20.00 per acre.

Contra Costa County.

There is no timber land in this county. The largest proportion of the total county tax is contributed by manufacturing corporations. An actual examination of the land is made annually. In taxing orchard land, the fruit trees are separated from the land. The tax rate was $1.50 per $100.00 in 1911. The average assessed value of the ranch land is estimated to be $35.00 per acre, of chaparral land $3.00 to $6.00 per acre, and of fruit trees $20.00 to $40.00 per acre. The assessor estimates the assessed value to be 60 per cent of the actual value. There are no sawmills in the county.

Del Norte County.

This county has a comparatively large area of timber land. Neither an actual examination nor a cruise of the timber is made. The assessed valuations have been raised about 60 per cent since 1906. In determining the assessed values, the trees are not separated from the land. The timber land is assessed at $20.00 to $67.50 per acre, and the average assessed value for spruce being $20.00 per acre, and for redwood about $35.00 per acre. It is estimated that 75 to 80 per cent of the total county tax comes from the timber lands. There are no plans of reform. Cut-over land is assessed at $3.00 to $5.00 per acre. The tax rate was $1.75 per $100.00 in 1911.

El Dorado County.

There is considerable timber land in this county. The county has no ownership of plats and shows a great lack of system. The trees are not separated from the land. No examinations or cruises are made. The timber land is assessed at $10.00 per acre, which is a great increase over 1910. The cut-over land is assessed at $2.00 per acre and the chaparral land at $2.50 to $5.00 per acre. The tax rate was $2.00 per $100.00 in 1911. The assessor estimates that the assessed value equals 50 to 60 per cent of the actual value. The general sentiment in the county is in favor of securing a better knowledge of the timber resources. There are no sawmills in this county.

Fresno County.

This county has a small area of timber land. No cruises or actual examinations are made of the timber land, and the trees are not separated from the land. The timber is divided into two classes, the first being assessed at $12.50 per acre and the second at $8.00 per acre. The tax rate was $1.64 per $100.00 in 1911. Cut-over and chaparral lands are assessed at $1.50 per acre. The actual value of timber land was estimated to be about $50.00 per acre. No plans of reform are being discussed, but the assessor is thinking of raising the assessed values.

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Glenn County.

This county has a small area of timber land. No cruises and the trees are assessed at $2.00, $3.00, $4.00, $5.00, $6.00, $10.00 per acre. Cut-over land is assessed at $2.00 per acr chaparral land at $2.00 and $3.00 per acre. The assessor that the assessed value represents 60 per cent of the actual va tax rate in 1911 was $1.82 per $100.00, depending upon t district. There was no talk of reform.

Humboldt County.

This county has a large area of timber land. No cruises and the trees are not separated from the land. Redwoo assessed at $15.00 to $60.00 per acre, pine and tan bark oa $2.00 to $10.00 per acre. Cut-over land is assessed at $4.0 per acre. The assessor estimates that the assessed value equ 50 per cent of the actual value, and that about 40 per cent of county tax was derived from timber land. The tax rate in $1.90 per $100.00. The general sentiment of the county was of cruising if it would not be too expensive.

Inyo County.

There is no timber land in Inyo County. The sage brus valued at about $3.00 per acre and the farm land up to $1 acre. The assessor estimates the assessed value to be about 60 of the actual value. The tax rate in 1911 was $2.00 per There are no sawmills in the county.

Kern County.

There is very little timber land in Kern County, and what is assessed at $1.33 per acre. Cut-over land is assessed at $12.00 per acre. The actual value of the timber land was to be $2.75 to $3.00 per acre. No cruises are made. The ta 1911 was $1.20 per $100. There is one sawmill in Kern Cou

Kings County.

Kings County has no timber land. The grazing land is as $2.50 per acre. The principal revenue of the county comes fruit lands. The fruit trees are assessed separately. Fruit land is assessed at $40.00 to $100.00 per acre. The tax rate was $1.65 per $100.00. There are no sawmills in the county.

Lake County.

This county is mostly agricultural and has very little tim No examinations and no cruises are made of the timber land trees are not assessed separately. Timber land is assessed at $4.00 per acre, cut-over land at $2.00 to $2.50 per acre and land at $1.25 per acre. The tax rate in 1911 was $2.15 per It was estimated that the timber land was actually worth $7.0 per acre. The assessor contemplates raising all the assessed the county.

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Lassen County.

This county has a large area of timber land. In 1905, this was cruised and classified by an expert cruiser. The timber land was divided into four classes, class A being assessed at $12.50 per acre, class B at $7.50 per acre, class C at $5.00 per acre, and class D at $2.50 per acre. The cut-over land is assessed at $2.00 per acre and the chaparral at $2.00 to $3.00 per acre. The assessor estimates that the assessed values represent about 30 per cent of the actual value. The timber land is recorded on separate plats. It was estimated that about 25 per cent of the total county tax was derived from the timber land. The assessor is contemplating raising the assessed values of the timber land. There was a flat rate of $2.50 per acre on the timber land in Lassen County previous to the cruises.

Los Angeles County.

There is no timber land in this county. In 1911 the tax rate was $1.20 per $100.00. The assessor estimates that the assessed values represent 25 to 40 per cent of the actual values. The fruit trees are assessed separately. There are no sawmills in the county. Chaparral land is assessed at $8.00 to $100.00 per acre, and fruit land up to $600.00 per acre.

Madera County.

This county has a rather small area of timber land. No cruises are made and the trees are not separated from the land. In 1911 the tax rate was $2.30 per $100.00. The assessed value of timber land was $10.00 per acre (will be $15.00 in 1912), of cut-over land was $1.50 per acre (will be $2.50 in 1912), and of chaparral $1.50 per acre. The assessor estimates that the assessed values represented 50 per cent of the actual value.

Marin County.

The timbered area in this county is small. There are no sawmills in the county. Cruises are not made and the trees are not separated. In 1911 the tax rate was $1.55 per $100.00. The assessed value of timber land was about $9.00 per acre and for cut-over land about the same. No plans of reform were being discussed.

Mariposa County.

There is considerable timber land in this county. No cruises are made, but examinations are made at irregular intervals. The trees are not assessed separately. The timber land is divided into two classes for assessment purposes, the first being assessed at $25.00 per acre and the second at $12.50 per acre. Cut-over land is assessed at $3.50 per acre and chaparral at $3.50 to $4.00 per acre. In 1911, the tax rate was $1.70 per $100.00. It was estimated that the actual value of the timber land was about $50.00 per acre. The assessed values were raised in 1911. The assessor estimates that 25 per cent of the total county tax was derived from timber land. There were no plans of reform in this county.

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Mendocino County.

The timbered area in Mendocino County is very large. No cruises and no actual examinations are made and the trees are not assessed separately. The timber land is assessed at about $10.00 per acre, the chaparral land at $2.50 per acre, and the cut-over land at $2.50 per acre. In 1911 the tax rate was $2.14 per $100.00. It was estimated that the actual value of the timber land ranged from $10.00 to $100.00 per acre. No change has been made in the assessed values for nearly ten years. The timber lands probably contribute about 50 per cent of the total county tax. The general sentiment is in favor of raising the assessed values.

Merced County.

There is no timber land in Merced County. Grazing land is assessed at $4.00 per acre, and farm land at $10.00 to $100.00 per acre, and chaparral land at $1.25 to $2.50 per acre. In 1911 the tax rate was $2.15 per $100.00. There are no sawmills in the county.

Modoc County.

There is a large area of timber land in this county. A cruise of the timber was made by the county surveyor in 1908 and 1909; it was divided, for assessment purposes, into three classes. Class A is assessed at $12.00 per acre, class B at $8.50 per acre, and class C at $5.00 per acre. Cut-over land is assessed at $2.00 to $2.50 per acre. The timber lands are recorded in a separate plat book, showing the class in which each subdivision belongs. Before this cruise was made, there was a flat rate of $2.50 per acre on all timber land. It was estimated that the actual value of the timber land is from $10.00 to $50.00 per acre. The assessor estimated about 33 per cent of the total county tax is derived from the timber land. In 1911, the tax rate was $1.60 per $100.00. The people of this county are well satisfied with the present system of taxation.

Mono County.

The timbered area in this county is small. No cruises are made and the trees are not assessed separately. Examinations are made very irregularly. The timber land is assessed at $2.50 to $3.00 per acre and the cut-over land at $1.50 to $2.00 per acre. The tax rate was $2.00 per $100.00 in 1911. The largest proportion of the county tax is derived from the grazing and farm land. The supervisors do not favor an increase in assessed values.

Monterey County.

This county has a rather small area of timber land. No cruises are made and the trees are not assessed separately. No actual examinations are made and there is a great lack of system in assessing the timber land. The timber, cut-over and chaparral lands are all assessed as grazing land at $1.25 to $4.00 per acre. The assessor estimated that the assessed values represented 45 per cent of the actual value. Fruit land is assessed at $15.00 to $225.00 per acre. There are no sawmills in the county.

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Napa County.

There is no timber land in this county. The principal tax revenue comes from the ranch land. The fruit trees are not assessed separately. Examinations of the land are made annually. Ranch and fruit land is assessed at $25.00 to $300.00 per acre, and chaparral land, which is used for grazing, at $2.00 to $5.00 per acre. The assessor estimated that the assessed value represents 50 to 60 per cent of the actual value. The tax rate was $1.76 per $100.00 in 1911. There are no sawmills in the county.

Nevada County.

The timbered area is rather small. No cruises are made and examinations are made at irregular intervals. The trees are not assessed separately. Timber land is assessed at $2.00 to $5.00 per acre, cut-over land at $1.00 per acre, and chaparral, which is used for grazing, up to $10.00 per acre. The assessor estimates that this represents about 60 per cent of the actual value. The tax rate in 1911 was $2.50 per $100.00. There were no plans for reform.

Orange County.

There is very little timber land in this county. The trees are assessed separately. The tax rate was $1.50 per $100.00 in 1911. The principal revenue comes from the orange and walnut groves. Timber land is assessed at $17.68 per acre, and the trees at $23.32 per acre. Fruit land is assessed at $25.00 to $225.00 per acre and the fruit trees at $50.00 to $225.00 per acre. Grazing land is assessed at about $5.00 per acre. The assessor estimates that the assessed value represents 30 per cent of the actual value. There are no sawmills in the county.

Placer County.

This county has a large area of timber land. No examinations are made, but the trees are assessed separately. The timber land is assessed at a flat rate of $1.00 per acre and the trees are assessed $3.00, $4.00, or $5.00 in addition. Cut-over land is assessed at $1.00 per acre and chaparral or grazing land at $4.00 to $10.00 per acre. It was estimated that the actual value of the timber land was $20.00 to $30.00 per acre. About 15 per cent of the total county tax is derived from the timber land. In 1911, the tax rate was $2.25 per $100.00. The assessor favors cruising, but the Board of Supervisors voted against this proposition.

Plumas County.

There is a large area of timber land in this county. No examinations and no cruises are made, but the valuations are raised from year to year. The timber land is assessed at $8.00, $10.00 and $12.00 per acre, chaparral land at $2.00 to $2.50 per acre and cut-over land at $2.00 per acre. The tax rate in 1911 varied from $1.65 to $2.80 per $100.00 depending upon the school district. The actual value of the timber land ranges from about $20.00 to $50.00 per acre. The assessor estimated that 65 per cent of the total tax was derived from timber land, 2 per cent from chaparral land, and about 1 per cent from the cut-over

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land. The present system is unsatisfactory and cruising the timber is being advocated.

Riverside County.

The timbered area in this county is small. The principal tax revenue comes from the fruit land. A four-year-old grove is assessed at $60.00 per acre and this is increased $30.00 per acre annually until $225.00 per acre is reached. The land and water rights are assessed separately and the maximum valuation for the three is $500.00 per acre. The tax rate was $2.10 per $100.00 in 1911, exclusive of bonded school tax. Timber and grazing land are not separated and no examinations of them are made. The assessor estimated that the assessed values represent about 30 per cent of the actual values. The present methods of taxation are unsatisfactory.

Sacramento County.

There is no timber or cut-over land in this county. An actual examination of all the land is made annually. Regular rules for assessing are in vogue. The tax rate was $1.69 per $100.00 in 1911, on land outside of cities. The assessor estimates that the assessed values represent 60 per cent of the actual value. Grazing land is assessed at $5.00 per acre, fruit and ranch lands at $15.00 to $500.00 per acre, and dredging land at $150.00 to $750.00 per acre. No plans of reform are being discussed. There are no sawmills in the county.

San Benito County.

There is very little timber land, but a great area of chaparral land in this county. In 1911, the tax rate was $1.70 per $100.00. Chaparral land is assessed at $1.00 to $2.50 per acre, cut-over land at $1.50 per acre, fruit land at $120.00 per acre, and fruit trees at $50.00 per acre. No actual examinations are made. The assessor estimates that the assessed value represents 45 per cent of the actual value. There are no sawmills in this county.

San Bernardino County.

The timbered area in this county is small, and the fruit land is the principal source of revenue. No cruises are made but the values are raised annually to allow for growth. Timber land is assessed at $2.25 to $7.50 per acre, cut-over land at $2.00 to $3.00 per acre, fruit land at $100.00 to $350.00 per acre, and fruit trees at $20.00 to $200.00 per acre. The assessor estimates that the assessed values represent 30 per cent of the actual value. The general sentiment is that the tax rate is too high and plans for reform are being discussed. In 1911, the tax rate was $2.50 per $100.00.

San Diego County.

This county has a small area of timber land, but the principal revenue comes from the fruit land. The tax rate was $2.00 per $100.00 in 1911. The forest trees are not assessed separately. The timber land is assessed at about $1.50 per acre, chaparral land at $3.00 to $5.00 per acre and fruit trees at 30 cents per tree. The assessor estimates the

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assessed value to be 30 per cent of the actual value. There is one small sawmill in the county.

San Joaquin County.

There is no timber land in this county, and the greater part of the revenue is contributed by the farm land. Ranch land is assessed at $10.00 to $300.00 and up to $1,000.00 per acre, in a few cases. Grazing or chaparral land is assessed at about $3.00 per acre. The assessor estimates the assessed values to be about 50 per cent of the actual values. There are no sawmills in the county.

San Luis Obispo County.

There is very little timber in this county. Apple and walnut lands are assessed at about $200.00 per acre for walnut land and $6.00 to $8.00 per acre for apple land. The assessor estimates the assessed values to be 25 per cent of the actual value. The tax rate in 1911 was $2.11 per $100.00. Chaparral and oak land is classified as grazing land and assessed $1.25 per acre. There are no plans for reform and no sawmills in the county.

San Mateo County.

There is a small area of timber land in this county. No cruises and no examinations are made. Timber land is assessed at $8.00 to $12.00 per acre, cut-over land at $2.00 to $5.00 per acre, and chaparral land at $2.00 to $50.00 per acre. The tax rate in 1911 was $1.85 per $100.00. No plans of reform were being discussed. There are four sawmills in the county.

Santa Barbara County.

There is no timber in this county, but there is a big area of chaparral land, which is assessed at $1.25 and $1.30 per acre. The tax rate was $2.34 and $2.74 per $100.00 in 1911. The general sentiment is that the present system is satisfactory.

Santa Clara County.

There is no timber land, but a great deal of chaparral land in this county which is assessed at $1.50 to $5.00 and up to $10.00 per acre in some cases. The tax rate in 1911 was $1.35 per $100.00. There are no sawmills in this county and no plans for reform.

Santa Cruz County.

Two thirds of the timber land in this county has been cut-over and is now considered as chaparral land. In 1911, the tax rate was $2.10 per $100.00. Chaparral land is assessed at $2.00 to $5.00 per acre, cut-over land at $5.00 to $8.00 per acre, timber land at $10.00 to $50.00 per acre, fruit land $50.00 to $200.00 per acre, and 25 cents to $1.75 each for fruit trees. The assessor estimates that the assessed value represents about 45 per cent of the actual value. No examinations and no cruises are made. The general opinion is that the assessed values of the timber land are too high. There are four sawmills in the county.

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Shasta County.

There is a large area of timber land in this count
are made at irregular intervals and some cruising is
are not assessed separately. The timber land is d
classes which are assessed as follows: Class 1 at $10.(
2 at $8.00 per acre; class 3 at $5.00 per acre, and clas
over land, at 50 cents per acre. Chaparral land is
to $2.50 per acre. It was estimated that 25 per cent o
tax is derived from the timber land and 8 to 10 p
chaparral and grazing land. The actual value of the ti
from about $16.00 to $60.00 per acre. The tax ra
$100.00 in 1911. The assessor is in favor of cruising

Sierra County.

The area of timber land in this county is large. No
and actual examinations are only made in case of c
are not assessed separately. Timber land is assessed
per acre and cut-over land at $1.00 per acre. Propor
are made when part of an area is cut over. The tax r
$100.00 in 1911. It was estimated that the average ac
timber land is about $25.00 per acre and of the cut-over
per acre. No plans for reform were being discussed.

Siskiyou County.

There is a very large area of timber land in this c
are not assessed separately and neither cruises nor act
are made. Timber land is assessed according to acc
and $7.00 per acre, and cut-over land at $1.00 per a
tax rate was $2.00 per $100.00. It was estimated tha
the total tax is derived from timber land, 15 per cent
desert and grazing land, and 5 per cent from the cut-
arral land is assessed at $2.50 per acre. The general
cruising. There are fifty-two sawmills in this county

Solano County.

There is no timber land in this county. The princ
comes from the fruit and ranch land. An actual exa
each year. The tax rate in 1911 was $1.60 per $
assessed at $10.00 to $300.00 per acre, and fruit tr
acre. The assessor estimates that the assessed value
70 per cent of the actual values. There are no sawm
and no plans for reform.

Sonoma County.

There is a large area of timber land in this county
made and the trees are not assessed separately. An ac
is made every four years. The oak land is assessed a
redwood at $8.00 to $50.00 per acre, cut-over land a
per acre and chaparral at $2.00 per acre. The assess
the assessed values represent 30 to 50 per cent of the

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believes this to be high enough. In 1911, the tax rate was $1.60 per $100.00. The principal revenue in this county comes from farm land.

Stanislaus County.

There is no timber land in this county, also there are no sawmills. The principal tax revenue comes from ranch lands. The tax rate was $1.85 per $100.00 in 1911.

Sutter County.

There is no timber land in this county, also no sawmills. Examinations of the land are made yearly. Pasture land is assessed at $2.50 to $10.00 per acre. The tax rate in 1911 was $1.50 per $100.00. The present system of taxation is satisfactory to the people.

Tehama County.

This county has a large area of timber land. No cruises nor examinations are made and the trees are not assessed separately. The timber land is divided into four classes, which are assessed as follows: Class 1 at $3.00 per acre; class 2 at $5.00 per acre; class 3 at $8.00 per acre, and class 4 at $10.00 per acre. Cut-over land is assessed at 50 cents to $2.00 per acre, and chaparral at $1.50 to $2.50 per acre. The average actual value of the timber land is estimated to be about $19.00 per acre. The people seem fairly satisfied with the present methods, but the general sentiment favors cruising.

Trinity County.

This county has a large area of timber land. No cruises and no examinations are made. The trees are not assessed separately. Timber land is assessed at $5.00, $8.00 and $10.00 per acre, very poor timber land is assessed at $2.50 and $3.00 per acre, cut-over land at $1.00 per acre and chaparral at $1.00 to $1.50 per acre. The actual value of the timber land is estimated to be from $10.00 to $20.00 per acre. In 1911 the tax rate was $2.60 per $100.00. The assessor estimates that the timber land contributes 50 per cent and the chaparral land 10 per cent of the total tax. The general sentiment of the county is in favor of cruising.

Tulare County.

This county has a rather large area of timber land. The trees are not assessed separately. No examinations and no cruises are made. Timber land is assessed at $2.50 to $30.00 per acre, cut-over land at $1.50 per acre and grazing and chaparral land at $2.50 per acre. The assessor estimates the assessed values to be about 50 per cent of the actual value. The tax rate was $1.70 per $100.00 in 1911. There were no plans for reform.

Tuolumne County.

There is a rather large area of timber land in this county. No cruises or examinations are made. The trees are not assessed separately. Ordinary timber land is assessed at $10.00 per acre. "Big Tree" tracts at $80.00 per acre, cut-over land at $2.00 per acre, and chaparral

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land at $1.25 to $3.25 per acre. The actual value of the ord timber land is estimated to be about $18.00 per acre. The tax r 1911 was $1.95 per $100.00. There were no plans for reform.

Ventura County.

There is very little timber land in this county. Most of the re comes from the fruit lands. Fruit land is assessed at $250.($300.00 per acre, and fruit trees at $1.00, $2.00, and up to $4.00 The tax rate in 1911 was $1.70 per $100.00. The timber is only locally and there is no systematic method for determining the valu of timber land.

Yuba County.

This county has considerable timber land. No cruises an examinations are made, but the assessed values are determined b general knowledge of the assessor. Timber land is assessed at per acre, cut-over land at $2.00 per acre, and chaparral and gra land at $2.00 per acre. The tax rate in 1911 was $2.40 per $10(There were no plans for reform.

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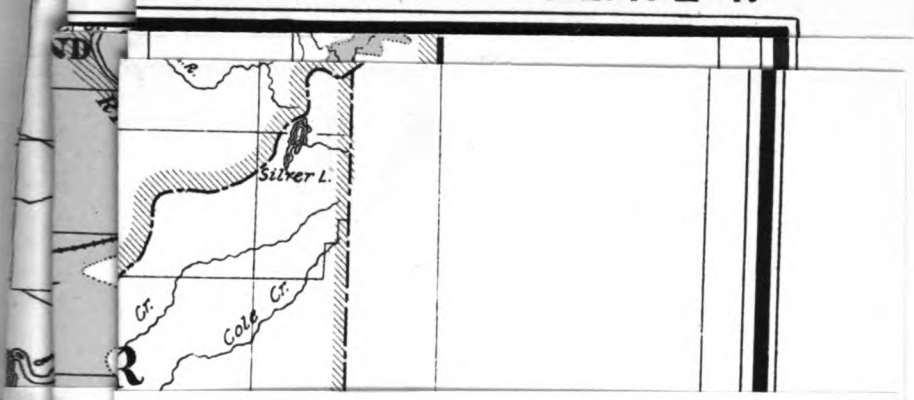
PLATE I.



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